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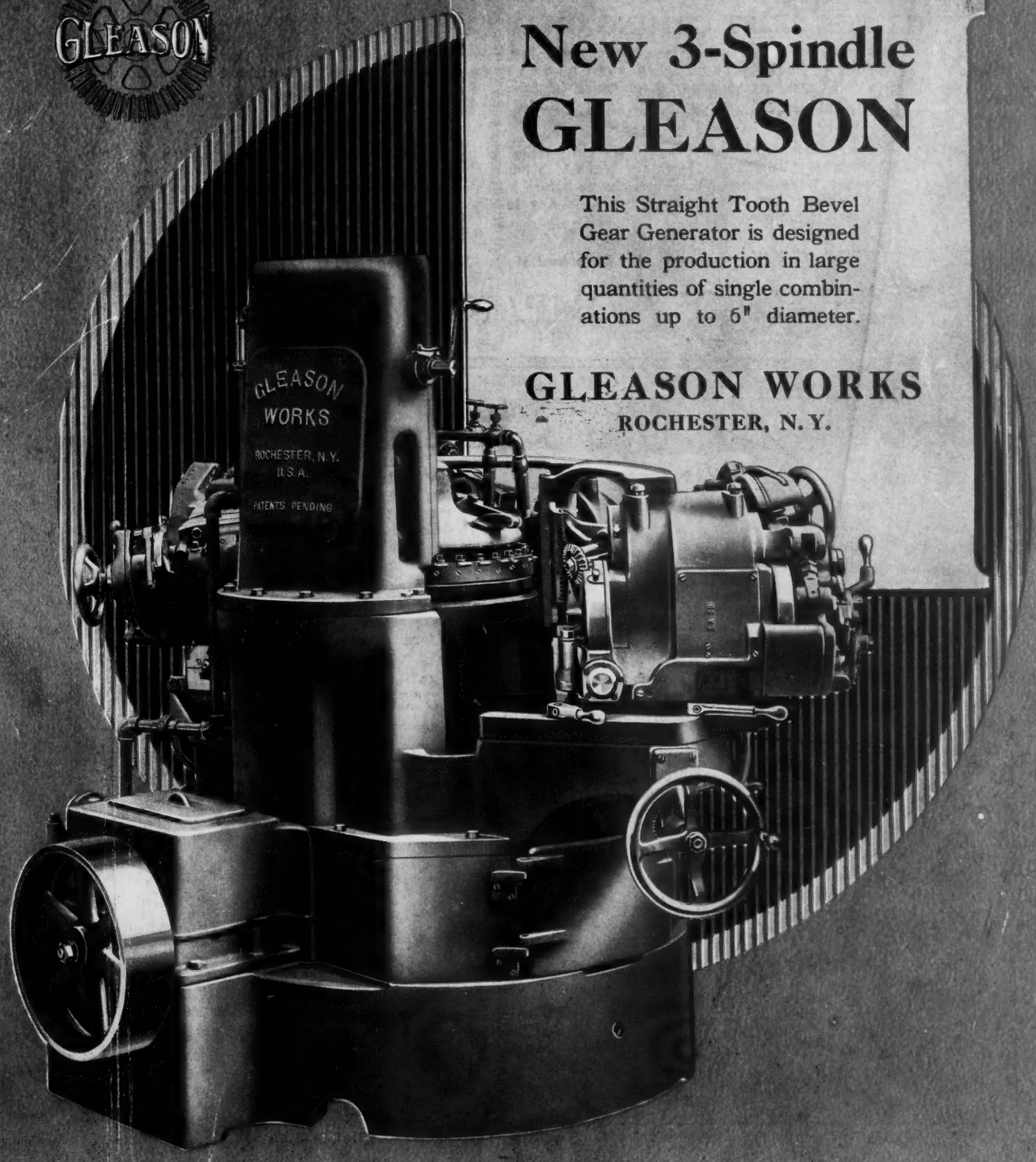

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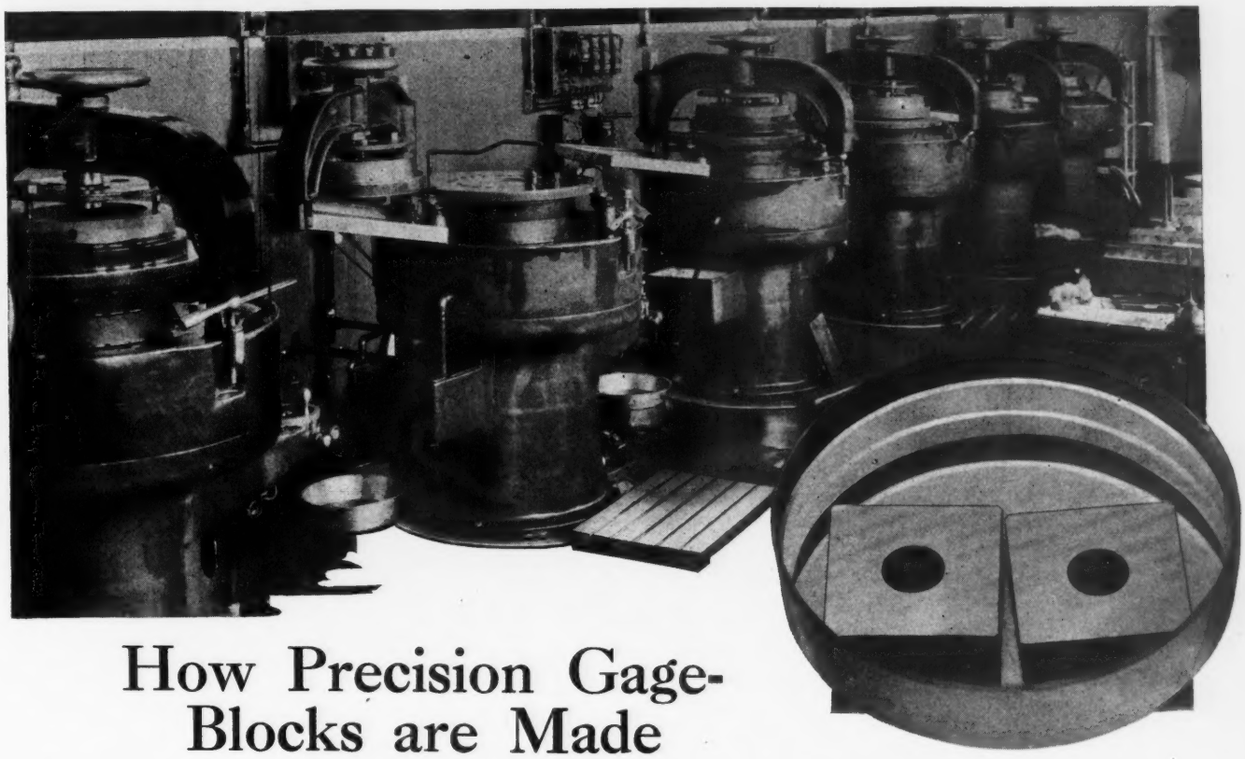


How Precision Gage-Blocks are Made

By FRANKLIN D. JONES

A Complete Description Covering Every Essential Detail in the Manufacture of Precision Gage-blocks at the Plant of the Pratt & Whitney Co., Hartford, Conn.

NO manufacturing process has been of greater interest or more puzzling to mechanics in general than the making of precision gage-blocks of the class which are often accurate within one-millionth of an inch. A steel block that is about one inch long is merely a piece of steel, but when, as the result of extremely refined lapping and measuring processes, it has been finished until the length is definitely known to be *one inch* within a limit of one-millionth, what formerly was simply a piece of steel becomes an object of great interest; it is also of considerable practical value as applied in maintaining the standards of accuracy necessary when manufacturing on an interchangeable basis. In fact, the plain block of steel which has been finished to such an extreme degree of accuracy represents a wonderful mechanical achievement and is an example of what can be done by scientific methods.

Now the making of a single block which is exceedingly accurate as to the flatness and parallelism of the end surfaces, is not easy, but, in the development of precision processes, the problem becomes vastly more difficult when it is necessary to produce a block which not only has flat parallel surfaces, but, in addition to this, is so close to a given length that the error—if it may still be considered an error—is frequently not over one millionth of an inch. If as a further requirement, a complete series of blocks is to be produced which progressively increase in size over a certain range of sizes, by steps or increments of only one ten-thousandth inch, the problem assumes even greater proportions. It is because of these exacting requirements that the users of precision gage-blocks, as well as many others interested in mechanical developments, have often wondered how these blocks are produced—especially in quantities—so that practically speaking, all error is eliminated. Just how this extremely accurate work is done at the plant of the Pratt & Whitney Co., Hartford, Conn., where the Hoke precision gage-blocks are made, will be explained in detail, beginning with the raw material, in the shape of steel bars, and taking up the various processes in successive order.

The manufacture of gage-blocks, which are flat, parallel and to a given size within a millionth of an inch—or at most a few millionths of an inch—is the greatest achievement in the art of precision lapping and measuring, as applied to a commercial product, and this article is the first complete illustrated description of a process which has been a mystery to so many men in the mechanical field. The article explains just how precision gage-blocks are made by the Pratt & Whitney Co., and deals with every essential feature, beginning with the kind of steel used, and continuing with the preliminary machining operations; the heat-treatment of the gages; the seasoning of the steel; the ingenious mechanical lapping process—which makes it possible to attain such marvelous accuracy—and the optical method of checking the finished gages.

Exacting Requirements in Gage-block Making

When gage-blocks are made so accurately that the most sensitive test known shows a very close approach to absolute perfection, it

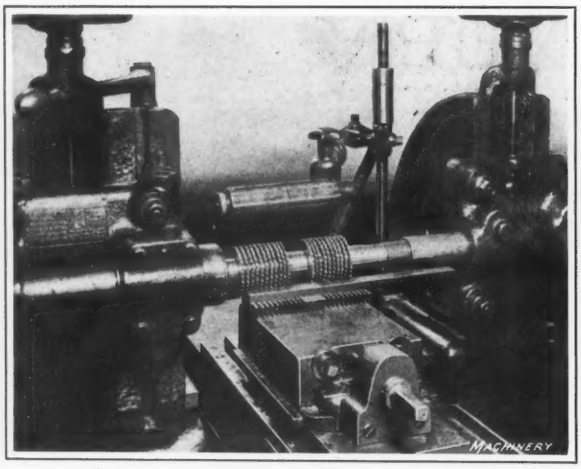


Fig. 1. Cutting a Steel Bar into a Number of Smaller Sections for making Gage-blocks

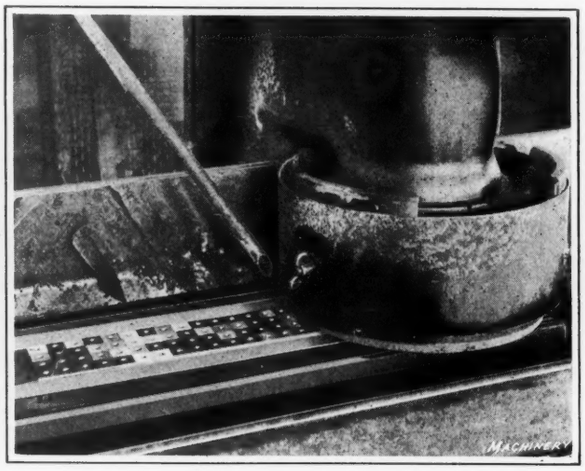


Fig. 2. Rough-grinding the Ends of the Gage-blocks on a Vertical-spindle Surface Grinder

will be realized that, first, there must be some method of forming these flat, parallel surfaces, and second, there must be a test for accuracy which is entirely reliable and not subject to the errors inherent in all forms of purely mechanical measuring apparatus. Before describing how these gages are made, the general requirements that are essential for gages of this kind will be summarized so that the reason for some of the processes to be described and their relation to precision gage manufacture will be more clearly understood.

1. The two gaging surfaces should be true planes.
2. The two gaging surfaces should be parallel to each other.
3. The length of the gage or the distance from one gaging surface to the other, should conform to a required dimension.
4. The gage-blocks of a set should differ in size or length by increments which make it possible to obtain any dimension within the extreme range covered by the complete set of blocks.
5. The difference between the length of any block in a set and the basic or standard length should be so small that even when a number of blocks are wrung together to form a composite gage, the combined error will still be within the limits set for the most accurate work encountered in practice.
6. The finished gage-block should possess the quality of permanence or stability so that it will retain its original accuracy of form and size and not be subject to minute changes. In this connection the steel should resist corrosion and wear as much as possible.

Steel Used for Precision Gage-blocks

As the kind of steel used for making gage-blocks has much to do with the ultimate success of the work, this will be considered first. Experiments were first made at the Bureau of Standards with low-carbon steel, heat-treated by pack-hardening, but precision gage-blocks made of this material lacked the important quality of permanence or stability. After careful investigation it has been found that a special chromium steel has the qualities that are essential for these precision gage-blocks. This steel contains from 1.20 to 1.50 per cent chromium; from 1.00 to 1.10 per cent carbon; from 0.20 to 0.40 per cent manganese; not over 0.03 per cent phosphorus; and not over 0.03 per cent sulphur. The chromium in the steel increases its resistance to corrosion and wear. Such a steel, properly heat-treated and seasoned, is relatively free from the changes in size and shape, which occur in all hardened steel very slowly and continue on an appreciable scale for several months after a gage has been finished. Incidentally, this steel is practically the same as is used for ball-bearing races. Every bar of steel that is to be used for making Hoke gage-blocks is subjected first to chemical and microscopic analysis to see that it conforms to the required composition and condition, and is also tested for hardness by the Brinell method and held within a narrow range. The gage-blocks, after heat-treatment, are again tested for hardness, the scleroscope method being employed.

Rough Machining Operations on Gage-blocks

If the steel bars pass the preliminary tests, they are sawed into suitable lengths. These bars are then straight-

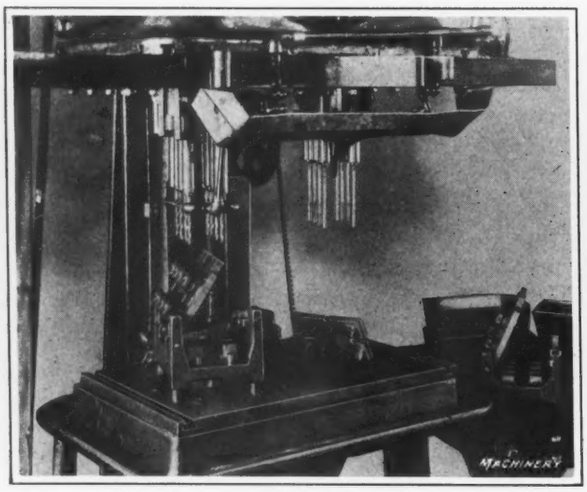


Fig. 3. Multiple-spindle Machine used for drilling Holes in the Shorter Gage-blocks

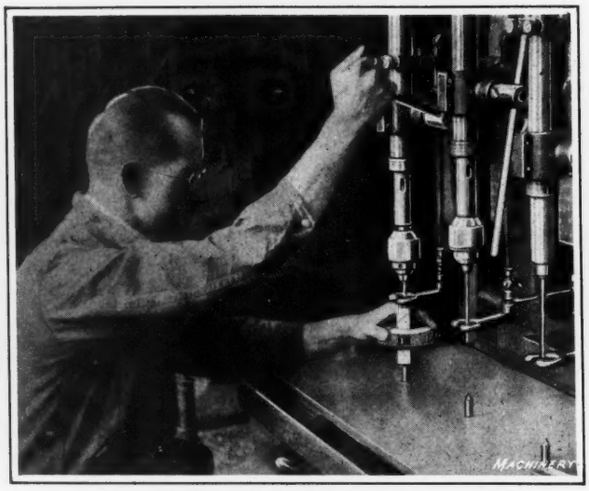


Fig. 4. Drilling Holes in the Longer Gage-blocks on a Gang Drilling Machine

ened if necessary, after which the four sides are ground on a Pratt & Whitney vertical-spindle surface grinder, the machine being similar to the type illustrated in Fig. 2. A number of the bars are held on a magnetic chuck and they are ground to 31/32 inch square, within 0.002 inch. After this preliminary grinding on the sides, the bars are placed in stock.

When a lot of blocks of given size are to be made, the first operation is that of cutting the bars into small blocks which are about 0.025 or 0.030 inch longer than the basic length. This operation of cutting off is done on a Pratt & Whitney automatic milling machine equipped with a gang of slitting saws as illustrated in Fig. 1. A bar of stock is held between slotted vise jaws, the slots being arranged so as to provide clearance spaces for the various cutters which pass through the slots.

The first operation on the ends or faces, which later are to be finished so accurately, is performed as illustrated in Fig. 2, a vertical-spindle surface grinder being used. Approximately one-hundred gage-blocks are placed in rows upon the magnetic chuck and are ground at the same time. This is a preliminary rough-grinding operation and the gages are reduced until they are about 0.020 inch over the basic length.

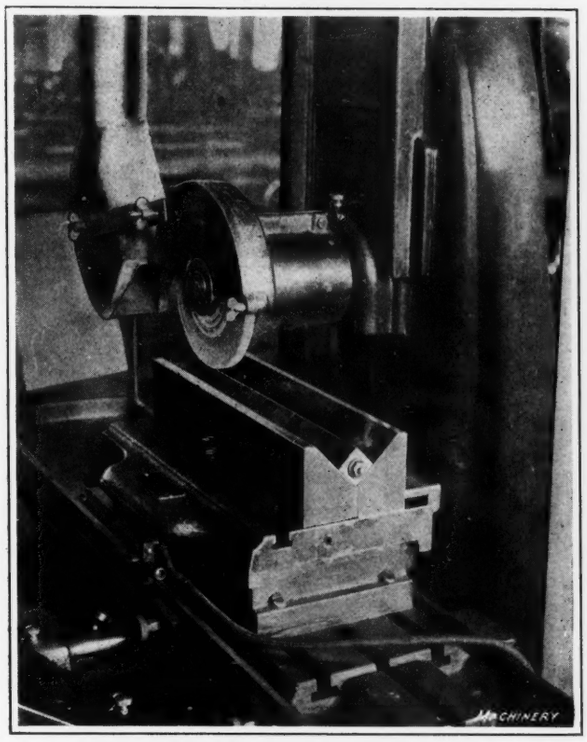


Fig. 5. Beveling the Corners of the Gage-blocks on a Surface Grinder

One of the characteristic features of the Hoke gage-blocks is the hole in the center. This hole, which is just large enough to receive a ¼-inch rod, makes it possible to bind a number of gages firmly together by passing a rod through them and using the clamping screws provided. The multiple-spindle machine on which these holes in the shorter blocks are drilled and reamed is illustrated in Fig. 3. After the drilling operation, the bushing plate, which contains all the drill bushings, is removed and replaced by another bushing plate preparatory to reaming. The longer gage-blocks are drilled on a gang drilling machine, while the lower ends are supported on centers as shown in Fig. 4. The next operation, which is that of countersinking, is performed on a bench lathe, and is followed by a burring operation for removing any sharp edges that may have been left in drilling. After these preliminary operations on the blocks have been completed, the gages are ready for the heat-treating process.

Heat-treatment of the Gage-blocks

As durability and permanence are very important factors in producing good gage-blocks, the heat-treating process is one of the most essential and also most critical operations in their manufacture. Even small variations in the condition or structure of the steel before hardening will result in unsatisfactory blocks unless careful attention is given to every small detail. Furthermore, the thickness or length of the blocks varies from under 0.050 inch to 4 or 5 inches, and a longer block, because of its greater bulk, requires a somewhat different treatment than a shorter or thinner one. Although the steel, as received from the maker, must have a certain specified structure within very narrow limits, the unusually exacting requirements of these gage-blocks make it necessary to "normalize" the steel still more uniformly.

As is common practice in many other cases, in order not to subject the material to a sudden change of temperature, the blocks are always preheated in a gas furnace before the final heating on all heat-treating operations. The normalizing process is the same for all blocks as regards their size, but is different according to the slight variations existing in the steel. It consists of heating the blocks uniformly throughout above the critical point in a gas furnace and then quenching in a niter bath. The niter bath is used as a quenching medium because it is less severe than oil would be.

Fig. 6. Testing Gage-blocks for Minute Flaws or Surface Cracks

The steel used in these blocks is very similar to the S.A.E. specification number 52100. The hardening and drawing of this steel follows approximately the S.A.E. heat-treatment "P." As these blocks are much smaller than most of the automobile parts for which this heat-treatment was developed, certain modifications are necessary. In hardening, the blocks are heated uniformly throughout, and the smaller blocks are quenched in circulating oil, while the larger ones are quenched in water. Naturally, the larger blocks are kept in the hardening furnace a much longer time than the smaller ones to insure a uniform heating. Furthermore, the temperature of the furnace when heating the larger blocks is slightly lower than when heating the smaller ones. Water is used as a quenching medium for the larger blocks, because a more severe quenching is required than on the smaller. The hardened blocks are next

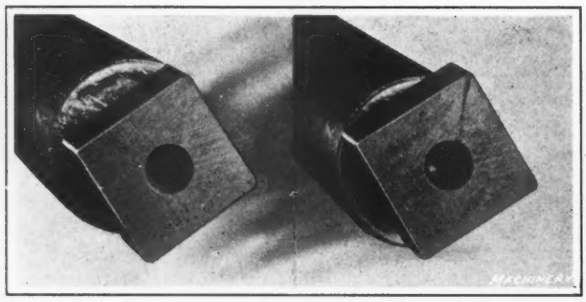


Fig. 7. Gage-block before and after being tested for Surface Cracks—the Right-hand View shows how a Crack is revealed by this Ingenious Test

drawn to 300 degrees F. in oil for a period varying from fifteen to thirty minutes, to relieve the hardening strains. After cooling in the atmosphere they are subjected to a further heat-treatment or special stabilizing process which has been developed at the Pratt & Whitney plant. This treatment, to be successful, must be controlled within an extremely narrow range of temperature, and is responsible, in large measure, for the permanence or stability of the finished gages.

It must not be understood from this that the blocks do not expand or contract with changes of temperature. It does mean that when a block is once made to a predetermined size at a specified temperature, it will always return

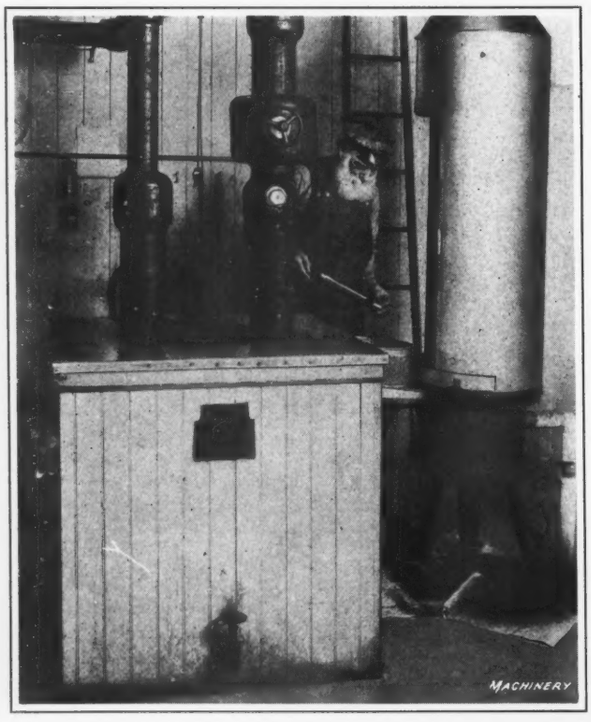


Fig. 8. Apparatus for seasoning the Gage-blocks by subjecting them to Alternate Changes of Heat and Cold

to that size when brought back to the original temperature, provided that it has not been exposed to temperature changes beyond the usual range of a shop. Furthermore, it is desirable to have shop standards which have approximately the same coefficient of expansion as the material being measured. In such cases, accurate measurements are made regardless of temperature, provided that the temperature of both the work and the gage is identical. After heat-treatment, the gages are cleaned by using "oakite" and are ready for the second grinding operation on the sides.

Rough-grinding the Sides and Ends

While no attempt is made to finish the sides of the gages to any great degree of accuracy, they are ground square and equidistant from the hole through the center. This is accomplished by placing a number of gages on a close-fitting rod and clamping them in position with a disk at one end, the diameter of which is equal to the width of the square. This row of gages is then ground on a vertical-spindle surface grinder, the wheel being fed down until it just grazes the disk, which thus serves as a gage for the four sides. The gages, which are now 0.950 inch square, are next tested with the scleroscope for hardness. The hardness should be from 85 to 95 on the scleroscope scale depending upon their length. After this hardness test, the ends are again rough-ground on a surface grinder, the gages being reduced to within 0.005 to 0.007 inch of the basic length. Two kinds

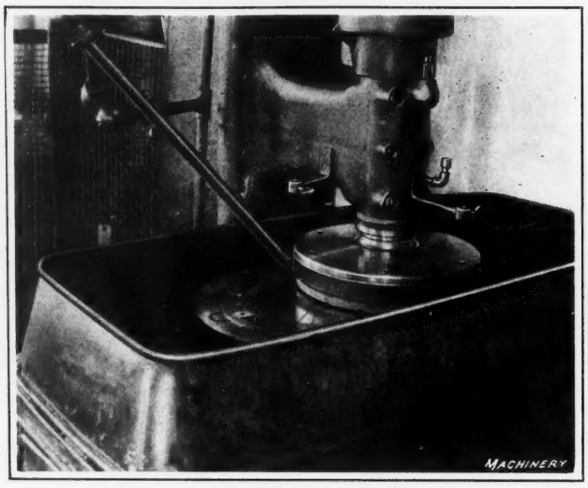


Fig. 9. Final Grinding Operation on the Ends or Faces of the Blocks prior to Lapping

of wheels have been used for this gage grinding with satisfactory results. One is a corundum wheel of 80 grain and ½ grade, and the other is an alundum wheel, made by the silicate process. The grain symbol for this wheel is 3880 and the grade H. A soft free-cutting wheel is used for this work in order to reduce the heating of the gages as far as possible.

The gages are next sand-blasted on the sides and then the corners are beveled slightly by grinding, as indicated in Fig. 5. A number of the gages clamped together are placed in a V-block, formed of steel and brass plates so that it serves as an auxiliary magnetic chuck when placed on the regular magnetic chuck of the surface grinder. The illustration shows how this simple operation is performed.

Detecting Minute Flaws or Surface Cracks

As every gage-block must be a perfectly sound homogeneous piece of steel, it is necessary to inspect each block carefully in order to detect the minute cracks which are liable

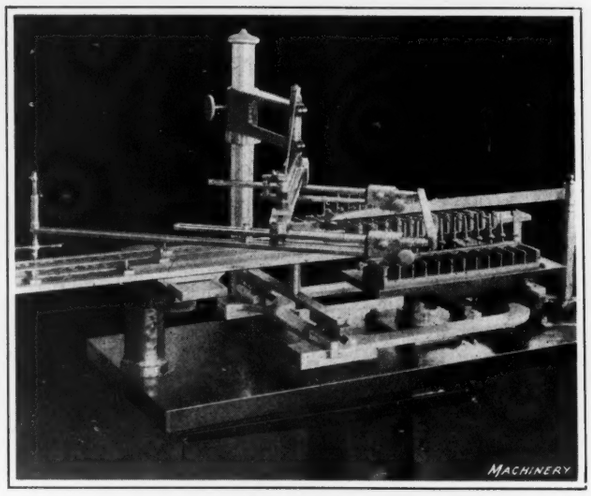


Fig. 10. Machine for marking Gage-blocks preparatory to etching Figures and Letters on the Sides

to form in any piece of steel, especially after it has been subjected to heat-treatment. Any flaws or cracks are detected by a very simple but ingenious method (see Fig. 6). The gage-block is immersed in a bath of kerosene which contains in suspension very fine steel dust, which is attracted by the residual magnetism in the block due to its contact previously with the magnetic chuck. Any minute cracks will be visible, especially when examined under the magnifying glass, because the lines of force interrupted by the crack cause the steel particles to form a dark line on the surface which shows the extent of the flaw. Fig. 7 shows a gage before and after being tested as described. This particular gage had a crack extending from one corner, as may be seen in the right-hand view. This illustration shows the end of an electromagnet which is sometimes used. These blocks are thoroughly demagnetized after the final grinding.

Seasoning the Blocks to Secure Permanence of Form

A precision gage-block, no matter how accurate it may be to begin with, is, of course, useless as a standard unless it retains its original accuracy. When gage-blocks are made so accurately that they can be used for obtaining a range of dimensions varying by only 0.0001 inch, it is evident that changes which ordinarily would not be considered become very important, because errors of only a few millionths are regarded as serious. In order to secure gage-blocks which will "stay put," each block passes through a seasoning process. As is generally known, steel and also castings, if allowed to stand for a long period of time, will gradually settle down to a more or less permanent state. This method of seasoning, however, is slow and usually impracticable as applied to manufacturing, and it is not necessary, as the same results can be obtained by an artificial process which is much more rapid.

This seasoning process consists in subjecting the gages to alternate changes of heat and cold. The apparatus shown in Fig. 8 is used for this purpose, and since a great deal depends upon this process—which might easily be slighted without detection—an old and trusted employe has charge of the work. A lot of the gages contained in a wire basket, are immersed in a bath, the temperature of which is well below zero, this temperature being maintained automatically by a refrigerating apparatus. After the gages have come to the temperature of this cold bath, they are quickly transferred to a bath which is heated to about 220 degrees F. After heating thoroughly, the gages are again transferred to the cold bath, and this successive heating and cooling is continued for several hours, which completes the artificial seasoning process. The blocks are then stored for a period of several months for aging and relieving any strains that may remain.

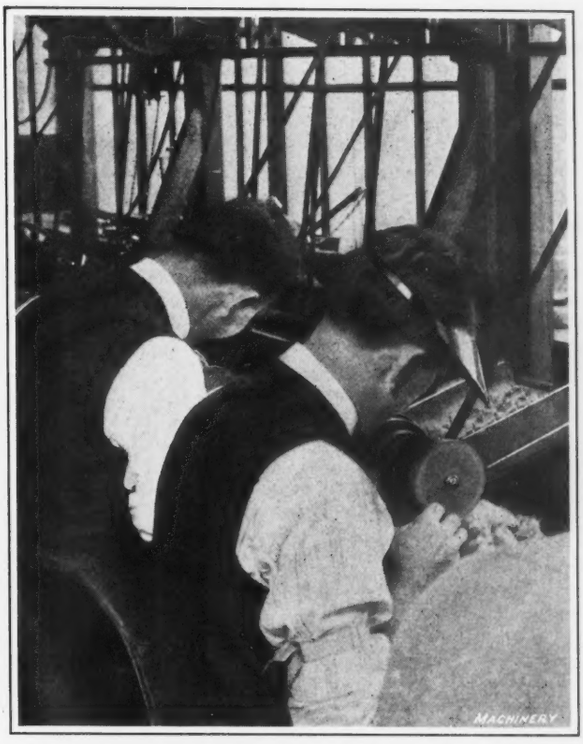


Fig. 12. Smoothing off the Corners of the Gage-blocks by means of Revolving Oilstones

Fig. 11. Stoning the Countersink at the Center of the Gage-block to remove All Sharp Edges

Final Grinding and Stoning Operations prior to Lapping

After seasoning and aging, the blocks are removed from storage for the final grinding operation on the ends or faces prior to lapping (see Fig. 9). The gages are reduced to within 0.0010 to 0.0012 inch of the basic size.

Fig. 11 illustrates one of the minor, but nevertheless important, operations on the countersink at the center. It has been found necessary to remove all sharp edges and corners, because such edges are liable to extend above the flat surface, and while this may be a very slight amount, still, it is a source of trouble. The finishing of the countersink is by means of a small conical pointed oilstone, which is shown in use in the illustration. The edges of the gages are next given a dull matt finish by means of a mud blast, and then they are ready for etching.

Etching the Gage-blocks

The size of every gage-block is marked on one edge or side, and on another side there is a special symbol for each gage, which enables it to be positively indentified. In addition to the size mark and symbol, the words Hoke Precision and the name Pratt & Whitney Co. are marked on the two remaining sides. This marking is done by the acid etching process. A coating of resisting material is first applied to the edges, and when this has been dried in an electric oven, a number of gages are placed on the multiple marking machine illustrated in Fig. 10. This machine is of the well-known pantograph type. As the pointer follows the enlarged letters on the brass pattern, marking tools reproduce the lettering, on a small scale, in the resist. A diluted solution of nitric acid is afterward applied and the figures and letters are etched in the steel.

Following the etching operation, all corners are smoothed off slightly by holding the gage-blocks against a revolving oilstone mounted on a bench lathe (see Fig. 12), and the gages are then ready for the final machining operation, which is that of lapping.

Lapping Machines which Finish Gage-blocks Flat and Parallel to a Millionth of an Inch

The gage-blocks, up to this stage, have been ground as flat and parallel as is possible on an ordinary surface grinder, and about 0.001 inch has been left for removal by lapping. Just how these upper and lower surfaces are lapped to the extreme degree of perfection necessary will now be explained. The lapping process, which is the invention of Major W. E. Hoke, from whom all rights have been acquired by the Pratt & Whitney Co., is entirely mechanical. The special lapping machines shown in Figs. 13 and 14 were developed by the Pratt & Whitney Co., and are used for this important work. A battery or row of these machines may be seen in the heading illustration. Each machine has two flat laps of circular form. The lower lap *A* (see Fig. 13) is attached to the base of the machine, and the upper lap *B* is secured to arm *C* by a connection which permits the lap to move freely in any direction but not to revolve. This arm is pivoted at one end so that the upper lap can be swung to one side to expose the lower lap and the work. When a machine is in use, one lap is above the other, as shown in Fig. 14, and the gage-blocks are between them, so that both the upper and lower surfaces of the blocks are lapped simultaneously. When the blocks are to be removed or inserted in the machine, the upper lap is swung out of the way, as shown in Fig. 13.

Fig. 13. One of the Machines used for lapping Precision Gage-blocks; the Upper Lap is swung to one Side to permit Insertion or Removal of the Blocks

Between these two cast-iron laps, there is a steel plate or "spider" *D* which contains twenty-four holes into which the blocks *E* to be lapped are inserted. These holes are slightly larger in diameter than the distance across the corners of the blocks, so that the latter are free to move and bear evenly on the faces of the laps. When the machine is closed, as shown in Fig. 14, and ready for use, this spider is about midway between the laps but does not come into contact with them. The function of the spider is to hold the blocks in position and impart to them the motion required for the lapping operation.

Action of the Mechanical Lapping Apparatus

The upper and lower laps remain stationary, while the spider receives a planetary motion which brings each block into contact with the entire surface of each lap. This motion of the spider is derived from three cranks *F* (see Fig. 13) which are attached to the upper ends of vertical shafts. At the end of each crank there is a pinion which is rigidly secured to the crank so that it cannot revolve about its own axis. These three pinions mesh with an external gear *G*, which is attached to the spider. At the lower ends of the vertical crankshafts there are connecting-rods operated by a central crank enclosed within the base of the machine. With this arrangement the three cranks are caused to rotate in unison, and as they revolve the spider is carried around between the pinions. The motion of the spider is partly indicated by the diagram, Fig. 17, which shows it in the four positions corresponding to 90-degree movements of the cranks. As these cranks revolve, their fixed pinions roll along the spider gear, and the spider itself is given a rotary motion about its own axis, while at the same time this axis follows a circular path having a radius equal to the crank radius. This combined motion carries the blocks inward and outward as the spider revolves. As it is very essential to distribute the wear on the laps as uniformly as possible, the machine is equipped with gears of such ratio that this gearing seldom occupies the same relative position. The result is that the spider and gage-blocks do not follow the same path around the surfaces of the laps, during successive turns. In fact, the cranks make about 300,000 revolutions before a given block in the spider again follows the same path relative to the faces of the laps. The wear is also further distributed by reason of the fact that the blocks themselves revolve with more or less irregularity at first and then quite uniformly and in the same direction, as the surfaces become true. When lapping comparatively long gage-blocks, considerable pressure is applied to the upper lap to prevent the blocks from tipping.

How the Mechanical Lapping Process is Controlled

The lapping process must be carried on so that the gaging surfaces gradually approach flatness and parallelism as the gage is being reduced to the correct size. While it would be relatively simple to lap the upper and lower ends until they are flat, it is very essential to so handle the work that both *flat* and *parallel* surfaces are secured either before or when the gage is finished to the required dimension. When the twenty-four blocks are first placed in the machine, there are sure to be very slight irregularities in regard to the heights of different blocks, as well as slight errors in the flatness and parallelism of their surfaces. As the upper lap is free to adjust itself, it naturally rests upon the three highest points or surfaces on the circular row of blocks, and as the blocks are carried around between the laps, these high areas are soon enlarged. Now if the lapping were continued without changing the blocks, the surfaces might be finished flat, but the plane of the upper surfaces would not be parallel to the plane of the lower surfaces, assuming

that there was some slight variation in height to begin with, as would ordinarily be the case. The problem then is to lap all the blocks flat and parallel while they are being reduced to the same length or height. This is accomplished by changing the relative positions of the blocks at intervals during the lapping period.

Just how the lapping is done will be illustrated by considering an actual example. The card reproduced in Fig. 15 shows in detail the various steps connected with lapping blocks having a nominal size of 0.550 inch. The figures in the column headed Size represent millionths of an inch, and in this particular case, approximately 0.0008 inch had to be removed by lapping. In order to have the lapping periods under accurate control, each machine is equipped with a combination revolution indicator and automatic stop which can be set to stop the machine after a given number of revolutions. This indicator and stop is in the form of a graduated dial and may be seen at *K* in Fig. 13. In the lapping operation, the history of which is recorded on the card, Fig. 15, the machine was first set to make 70 revolutions; then, after transposing the blocks, as explained later, it made 70 more revolutions. As the result of the lapping due to 140 revolutions, the blocks were reduced (as shown by the figures in the left-hand column) from plus 800 millionths of an inch to plus 400 millionths. Sixty additional turns reduced the blocks to within 225 millionths of the required size, and then a number of other lapping periods followed, until the gage-blocks were only 15 millionths over size. The machine in this case was then set to make 50 revolutions, which gave the additional reduction required.

Transposition of Gage-blocks to Eliminate Errors

The transposition of the blocks is a very essential part of the work, and if this were not done, it would be impossible to lap the opposite surfaces of the blocks flat and parallel at the same time. Whenever a set of rough blocks is placed between the laps, the upper lap is sure to rest upon the three highest points or areas, and if the upper lap were in an inclined position to begin with, it would ordinarily tend to remain out of parallel with the lower lap. To avoid this lack of parallelism, the minute errors in heights of different blocks are gradually eliminated by the following method: After the machine has made a certain number of turns, the upper lap is swung out of the way and every other block is moved 180 degrees, or to a position diametrically opposite. For instance, in the example illustrated by the card, Fig. 15, the automatic stop is first set for 70 revolutions and then the blocks are moved. As the result of this shifting of the blocks, either the highest one in the set or the one next to it, is moved across the plate, and owing to these changes of position, height errors are reduced about one-half. Sometimes the blocks are shifted only 90 degrees, thus further dividing and reducing the error, and by repeatedly changing positions, the upper surfaces are finally brought into parallelism with the lower surfaces.

By referring to the card, Fig. 15, it will be noted that there is no fixed relation between the number of revolutions and the amount of reduction by lapping. This is due to the fact that as the blocks are transposed and occupy different relative positions between the laps, the high areas, in some cases, are quickly reduced, whereas for other positions, the surfaces are more nearly in the same plane, and, consequently the laps are in contact with larger areas, and any reduction in the height of the blocks requires much more time. For instance, it will be seen that 20 revolutions served to reduce the blocks from 225 to 200 millionths, and then 30 revolutions more did not result in any appreciable change. The next lapping period, however, of 40 revolutions again reduced the size 25 millionths.

The Laps Used for Precision Gage Work

The laps used for these precision gages are charged with a fine grade of Turkish emery, which has been found superior to artificial abrasives for this particular work. The charging of the laps takes place at the time they are ground in, as explained later. A slight amount of additional abrasive is also applied to the laps during the early stages of the lapping process. This abrasive is mixed with kerosene which is pumped through pipe *J*, Fig. 13, to the upper lap which is provided with a channel *H* extending around the outer edge, and holes through which the oil flows to the space between the laps.

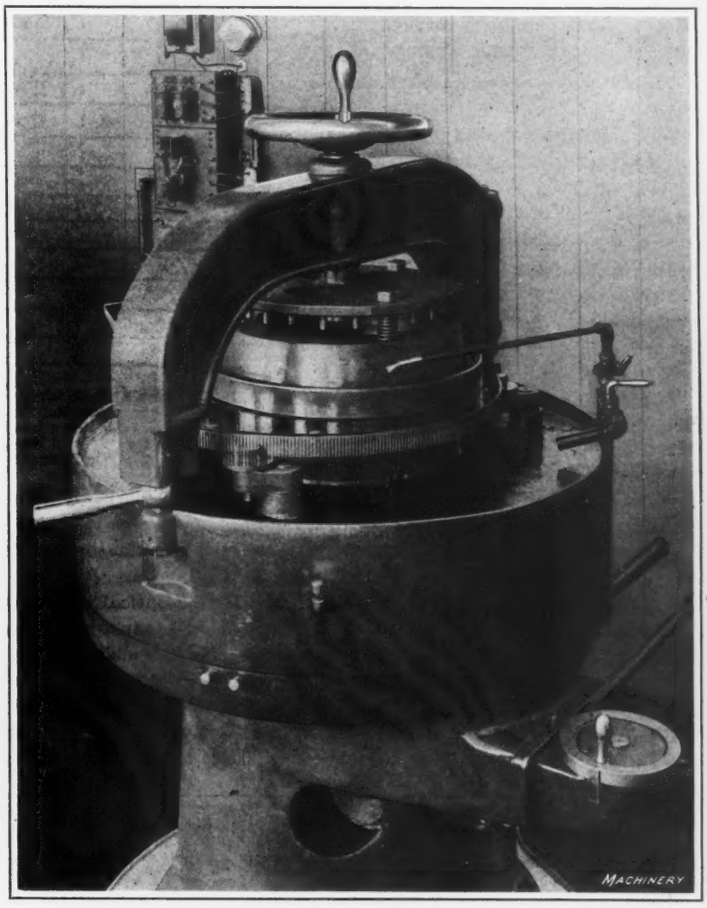


Fig. 14. View of a Lapping Machine, Closed and Ready for Use

Much depends upon the accuracy of these laps; they are made of gray cast iron, which is homogeneous and entirely free from any porous or spongy places. In order to eliminate all internal stresses and prevent subsequent changes, the castings are thoroughly annealed and seasoned. They are next rough-machined and then are further seasoned by the alternate heating and cooling method, using the same apparatus as for the gage-blocks.

The lapping surfaces which come into contact with the gage-blocks are next planed. The finishing cut is taken with a broad, flat tool and with a fairly coarse feed. After planing, the laps are scraped to a master plate, and then ground together. This grinding-in process is similar to the well-known triple method of making surface plates and straightedges, which is based on the principle that three surfaces cannot fit together interchangeably unless they are true planes. For example, laps Nos. 2 and 3 are first ground in with lap No. 1. Then the order is varied by grinding in lap No. 2 with lap No. 3, and then lap No. 1 with lap No. 2,

and so on. In this way, errors which would be transferred from one plate to another if only two plates were made, are eliminated and plane surfaces are generated.

This grinding in of the laps is done on an ordinary drilling machine (see Fig. 16) equipped with a crank for giving one lap a planetary motion. The fine grade of Turkish emery used for grinding in the laps becomes embedded in the surface, so that when the lap is finished it is also charged and ready for use. The newly ground laps are used on the finishing machines, and those which have become worn slightly through use are applied to the rough lapping.

Measurements of Calibrated Standards or Master Gages

The Hoke precision gages are guaranteed to be flat, parallel, and to the specified lengths within five-millionths of an inch, plus or minus, of basic size up to ½ inch, with a tolerance of ten-millionths of an inch plus or minus, per inch of length for the larger sizes. Incidentally, this tolerance is approximately equal to the expansion of the steel used, with a temperature change of one degree centigrade. The gages are well within these maximum tolerances, and frequently are not more than one- or two-millionths from the exact size. How is it possible to determine when a gage is of a given length within a millionth of an inch?

Operator Smith
Machine Number 4
Nominal Size 0.550
Type Hoke

Size	Time or Rev.
+800	2 × 70
+400	2 × 30
+225	20
+200	30
+200	40
+175	50
+100	2 × 20
+100	2 × 20
+100	2 × 50
+75	2 × 50
+50	2 × 20
+50	2 × 40
+30	40
+30	60
+20	50
+15	50
O.K.	

Fig. 15. Sample Card which shows how Blocks having a Nominal Size of 0.550 Inch were gradually reduced to the Correct Size by the Mechanical Lapping Process

In the production of precision gage-blocks on a manufacturing basis, the gages are compared with master blocks or calibrated standards, by the application of a simple optical principle. But before this can be done, the standards must be calibrated, which requires special optical apparatus and very careful observations, corrections, and calculations. These fundamental measurements of the master blocks used by the Pratt & Whitney Co. were made at the Bureau of Standards. The process, reduced to a few words, involves determining the number of light waves between the planes or faces of the standard or block being measured. In connection with this work, the character of the source of light must be determined, and corrections must be made for various conditions which affect the results, such as atmospheric pressure, humidity, etc. Complicated mathematical calculations are also necessary, so that making one of these fundamental measurements is a scientific undertaking, and considerable time is required to determine the size of a single block. In fact, two men working together can measure only about three blocks in a day.

When the number of light waves between the upper and lower surfaces is known, the length of the gage can be determined with great accuracy, because the length of the standard meter, in terms of light waves, has been determined with such accuracy that the error is negligible. After standards have been measured in this way and their errors are known, they can be used as a direct means of comparison with the gages in process of manufacture. The masters used are generally not absolutely correct, but a table of errors enables the operator to make the necessary corrections.

When the gage-blocks are being lapped to size, an amplifying gage of the type shown in Fig. 18 (made by the American Gage Co., Dayton, Ohio) is used as a means of ascertaining the gradual reductions in size, before applying the more sensitive optical test which is only required for the extremely fine measurements. The indicating dial of this gage is graduated to 0.0001 inch, and the gage is so sensitive that a variation in size of 0.00001 inch can be detected. This gage is first set by using calibrated standards (as shown in the illustration) so that the blocks, as they are being lapped to size, can be compared directly with the standards. The smaller gages are tested in multiple, a number being wrung together so that

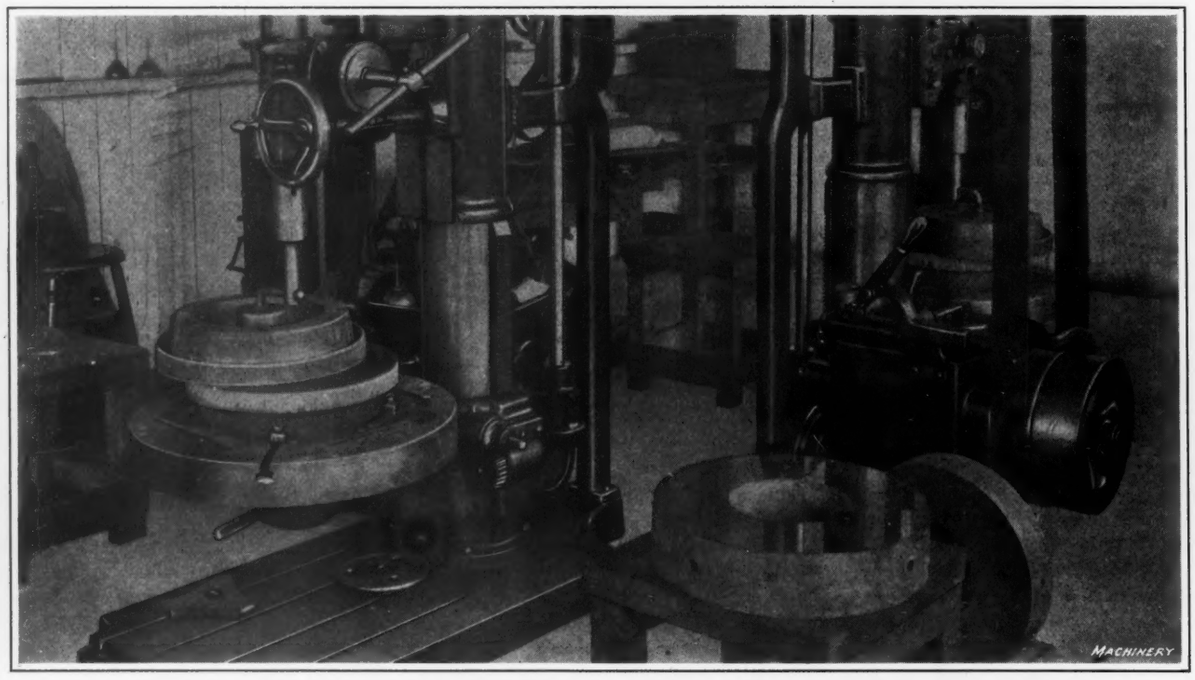


Fig. 16. Machines used for generating Plane Surfaces on the Laps by grinding them together, the Process being Similar in Principle to the Well-known Triple Method of making Surface Plates

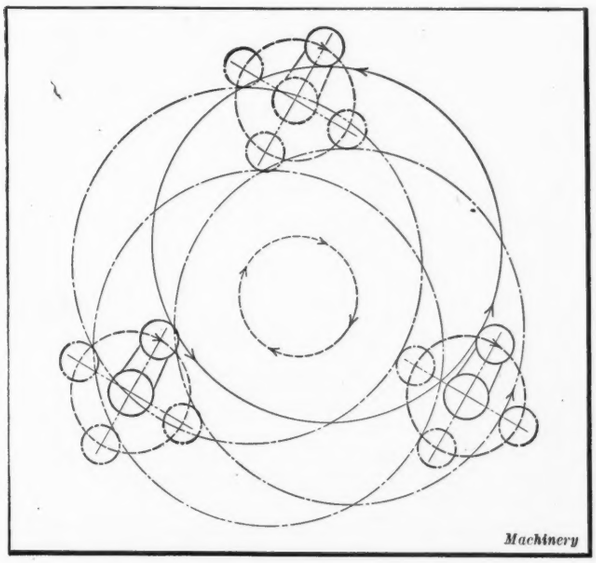


Fig. 17. Diagram illustrating the Planetary Motion of the Plate or "Spider" which moves the Gage-blocks around between the Stationary Lapping Surfaces

a test for height shows the combined error instead of the relatively small error in one block. The amplifying gage or comparator is used until the gages have been lapped practically down to size. Then the optical test is applied to each block to determine whether both end surfaces are flat and parallel and whether the block is of the correct length. As

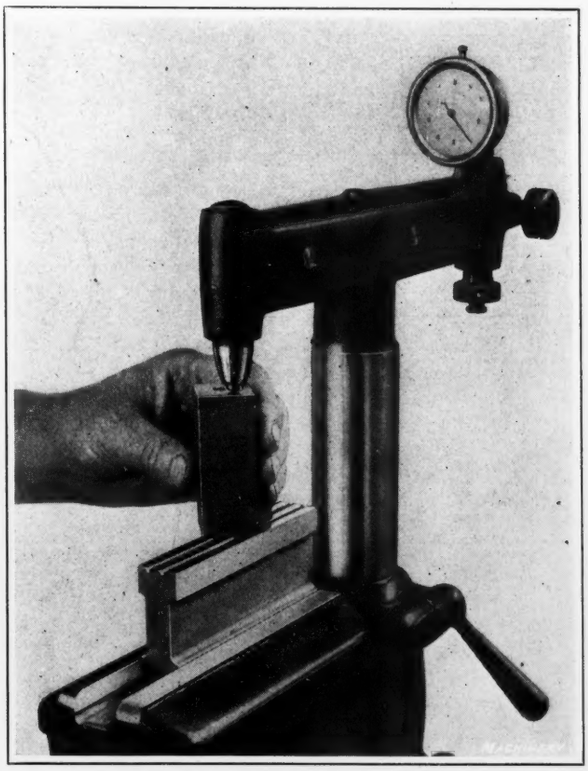


Fig. 18. Amplifying Gage used to show the Gradual Reductions in the Sizes of the Gage-blocks before applying the More Sensitive Optical Test

the lapping operation heats the gages somewhat, it is necessary to allow sufficient time for the blocks to come to the room temperature before measuring.

Optical Method of Testing Gages for Flatness

The apparatus used for the final test of accuracy is shown in Figs. 19 and 20. This apparatus and the method of testing are simple but wonderfully accurate. The equipment consists of a Cooper-Hewitt mercury-vapor lamp; a ground glass beneath the lamp to diffuse the light; and "optical flats" or glass plates which are such perfect planes that errors cannot be detected. If one of these optical flats is placed over a block, the light from above, after passing through the glass plate, will be reflected from the lower surface of this plate and from the upper surface of the gage-block, and as the result of the interference of the light waves (a phenomenon explained in treatises on optics) a series of alternate light and dark bands becomes visible, assuming that the flat is properly applied.

These "interference fringes" or bands would not be visible if a perfectly flat gage were wrung into close contact with the optical flat. In this case, the surface of the block as

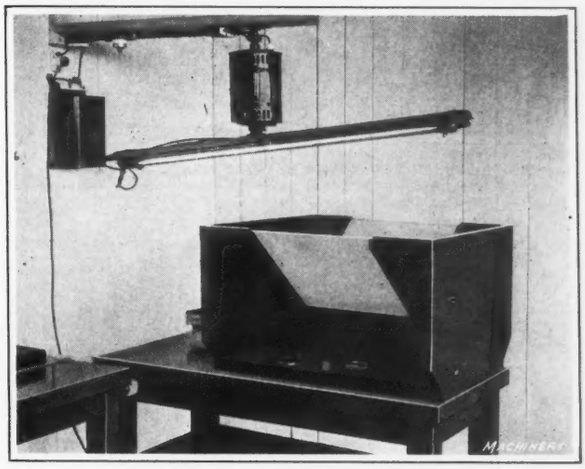


Fig. 19. Optical Apparatus used for testing the Accuracy of the Gage-blocks

seen through the glass beneath the light, would have a steely or grayish hue, wherever there was close contact, and any slight lack of perfect contact would be indicated by a tinge of yellow. If the optical flat were applied to this same block with only one side or edge of the block in close contact, there would be a thin wedge-shaped space or film of air between the flat and the surface of the block and then the interference fringes would be visible. If these bands are parallel and straight or nearly so (as shown in Fig. 21, which illustrates the optical test applied to a toolmaker's "flat"), this indicates that the surface is accurate as to flatness, assuming that the bands remain parallel and straight

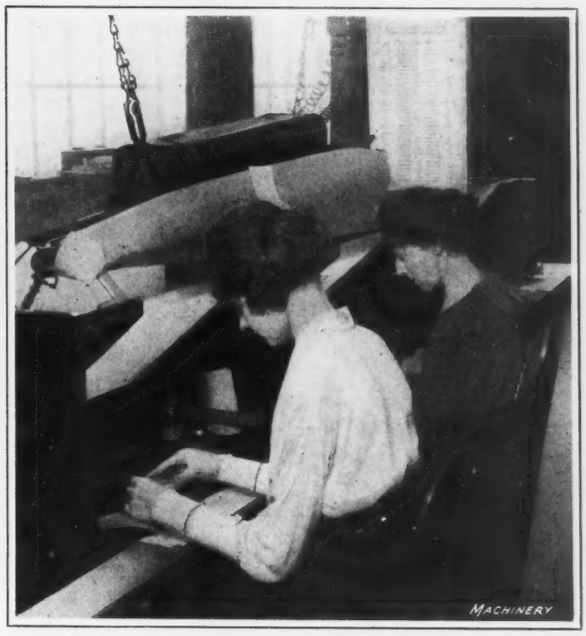


Fig. 20. Another View in the Laboratory, showing Gage-blocks being tested for Accuracy by the Optical Method

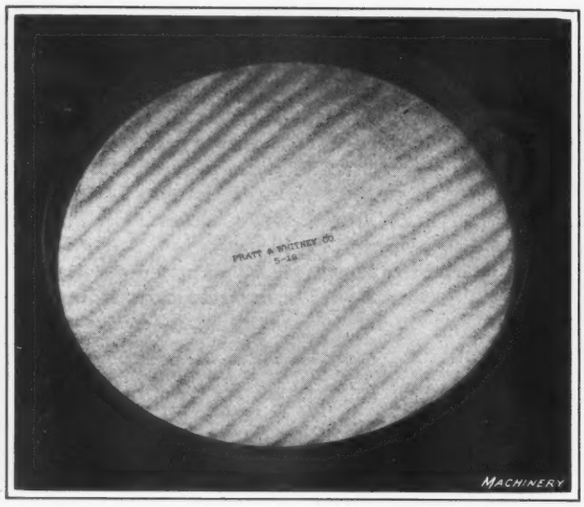


Fig. 21. The Optical Test applied to a Toolmaker's Flat; the Approximate Straightness of the Bands or Interference Fringes indicates that the Surface is nearly a True Plane

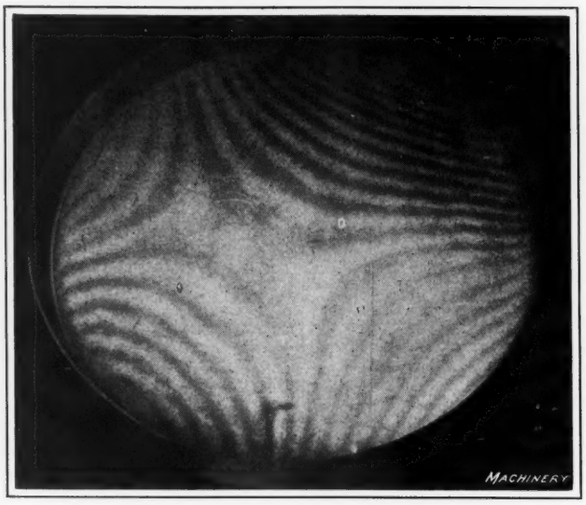


Fig. 22. Optical Test applied to a Toolmaker's Flat which is not Accurate. The Extent of the Error is indicated by the Amount that the Bands curve

after the optical flat is placed in contact with an adjacent edge so that the inclination of the flat is at right angles to the first position.

When testing for flatness, the bands literally form a contour map of the surface of the gage-block. For instance, if the surface is not flat, the extent of the error is indicated by the amount that the bands curve (see Fig. 22); and any one band coincides with that part of the untrue surface which is on the same level. The distance from one band to the next (whether the bands are straight or curved) increases as the optical flat is pressed closer to the gage, owing to the change in the angle of the wedge-shaped space or film; but regardless of what the actual distance is, this space represents about ten-millionths of an inch. Thus if the height of the arc formed by a curved band, within the width of the gage, is equal to the distance between adjacent bands, this shows that there is an error of about ten-millionths of an inch; or, if the height of the arc were only, say, one-tenth of the distance between the bands, this would indicate an error of one-millionth inch.

While straight parallel bands indicate a flat surface, it is necessary to place the flat in two positions with the respective lines of contact along two edges of the block at right angles to each other, in order to obtain an absolute test. This point is illustrated by the application of the flat to a surface which has a very slight curvature but is truly cylindrical. In this case, the bands would be parallel, provided the line of contact with the flat were parallel with the axis of the cylindrical surface, and this would hold true whether the surface were convex or concave. The parallel bands, however, would not be uniformly spaced, as in the case of a perfectly flat surface, although this irregularity of spacing might not be noticeable for very slight curvatures. This curvature would be readily detected if the flat were applied with the contact line at right angles to the first position, because curved bands would then be seen. The bands would be parallel for the first position, because the only effect of the curvature would be to increase or decrease the thickness of the air film, and as any axial surface line would extend squarely across the wedge-shaped space and be parallel to the surface of the flat, the bands would be straight for this one position, and the lack of uniformity in spacing would be the only indication of curvature.

Tests for Parallelism and Length

While the flatness of a surface can be tested by using a single optical flat, as just described, it is necessary to determine whether the two end surfaces of each gage-block are parallel to each other and the right distance apart. In order to do this, two optical flats and a calibrated standard block are used. The standard block and the gage to be tested are wrung upon one of the flats and placed close together. Then the other flat is applied to the upper surface (see Fig. 23) so as to obtain contact at points along the same side of each block. If both upper surfaces are flat and lie in exactly the same plane, a series of continuous parallel bands will extend across the two blocks, but if the bands above the two blocks incline in different directions, this shows that the

Fig. 23. Applying an "Optical Flat" or True Glass Plane to a Gage-block which is being compared with one of the Calibrated Standards or Master Gages

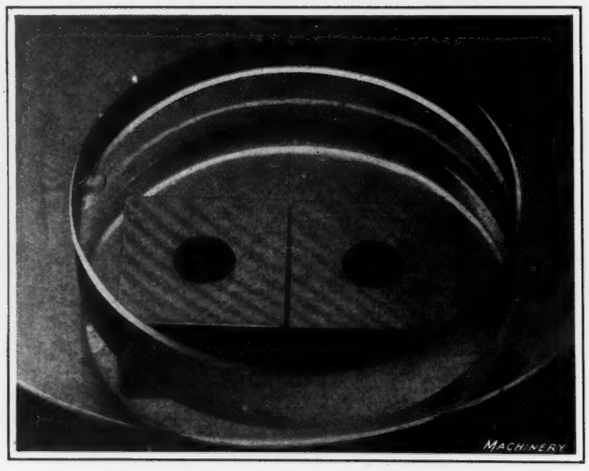


Fig. 24. View of Gage-block (at Left) and Calibrated Standard (at Right) as seen through an Optical Flat which is placed over the Blocks when testing for Accuracy

surfaces are not in the same plane and that the two planes are not parallel. When the surfaces are parallel but not exactly the same height, the bands incline in the same direction, but those over one block will be offset in relation to the bands over the other block. Fig. 24 shows an optical flat applied to two blocks; a calibrated standard is at the right and the gage-block being tested, at the left. In this case the bands show that the upper surfaces are about parallel, although they are not the same height, and the block to the left is not exactly flat, as indicated by a slight curvature of the bands.

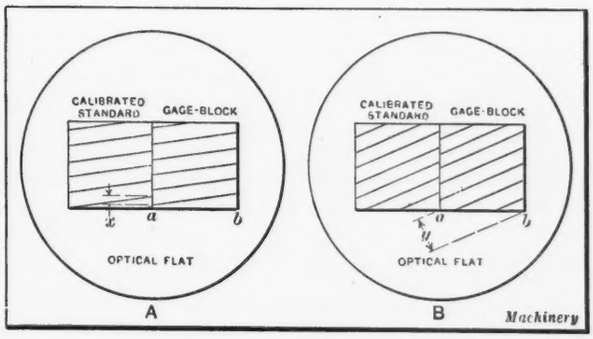


Fig. 25. Diagram illustrating how the Amount of Error is determined

When a flat is first applied to two blocks, if a series of continuous parallel bands extend across both surfaces, this shows that these surfaces are in the same plane; it does not follow that the upper surfaces are parallel with the lower ones which are in contact with the bottom flat. For instance, both upper surfaces might be in exactly the same plane, but inclined slightly in relation to the lower surfaces, although such a condition would be unusual in actual practice. Any such lack of parallelism between the upper and lower surfaces would be readily detected, because after a block is tested in one position, it is turned 90 degrees and the flat is again placed over this block and the standard. Any lack of parallelism between the upper and lower surfaces is revealed by this change of position, because the bands incline in different directions.

How the Amount of Error is Determined

The amount of error, expressed in fractional parts of an inch, is determined by noting the positions of the interference bands relative to each other and to the points of contact between the blocks and the flat. As an example, suppose there is only a slight error in height or thickness, the surface of the gage-block being a few millionths of an inch below the surface of the standard. When the flat is applied, it is placed in contact with the corner of each block as at a and b (see diagram A, Fig. 25), which makes it necessary to tilt the flat slightly. As the result of this slight inclination of the flat, due to the difference in the height of the blocks, the bands extend diagonally across the surfaces, because the wedge-shaped spaces are in a diagonal position relative to the block, and the more the flat is inclined on account of the difference between the height of the two corners, the more the bands will incline; this inclination is an indication of the amount of error when properly interpreted. The diagram A illustrates a difference in height of only about five-millionths of an inch, which is shown by the fact that the bands over one block are offset relative to the bands over the standard block, a distance x equal to one-half the distance between adjacent bands. In this case, the error is indicated directly by the amount of offset x, but if the error exceeded ten-millionths, which is the amount, in round numbers, represented by the distance between adjacent bands, it would be necessary to consider the total amount of offset. For example the difference in the height of corners a and b of diagram B, is about two and one-half interference fringes, as indicated by y, so that the error is approximately twenty-five-millionths inch, and is determined in this case by considering the relation between the bands and the two points of contact.

This simple and extremely accurate method of using optical flats as a means of checking the relative sizes of gage-blocks, was first applied by Dr. C. G. Peters of the Bureau of Standards. If every block had to be measured by using an interferometer, the impracticability of such a slow process in connection with gage manufacture is apparent. The optical-flat method, which is a simple application of the interferometer principle, places the most accurate known method of checking gage-blocks on a manufacturing basis.

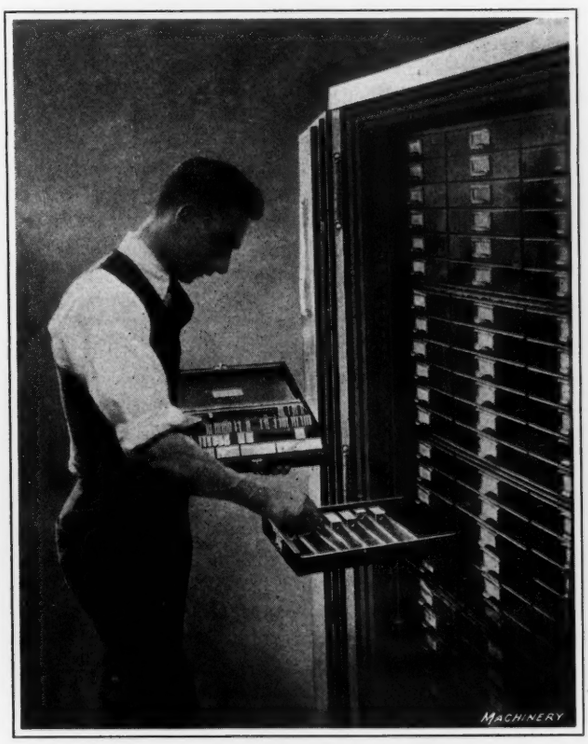


Fig. 26. Safe for storing Gage-blocks certified by the Bureau of Standards

Fig. 27. Another View in Department where Finished Gages are stored

Maintaining a Constant Temperature in the Laboratory

In the laboratory where these gage-blocks are lapped and tested for accuracy, it is essential to maintain a constant temperature, as the blocks will change in length as the temperature increases and decreases, so that the size marked on each block must represent the size for some temperature. The standard temperature for the Hoke precision gage-blocks is 68 degrees F. This temperature, as well as the humidity of the laboratory, is automatically maintained by special apparatus. If this standard room temperature were not maintained, difficulties would also be experienced in producing the gage-blocks, because a uniform temperature throughout each block is essential. For instance, if there were decided temperature changes, such as would occur frequently without means of regulation, the temperature of the blocks might change between the lapping and testing periods, and the outside would be slightly warmer or colder than the inside, so that a block which checked with the standard one day would be inaccurate the next. When the blocks are being compared with the calibrated standards, care is taken to avoid heating them by contact with the hands. The optical test is so sensitive that it shows very quickly the increase in the size of a block which is held in contact with the end of a finger. The motors which drive the lapping machines are placed outside of the laboratory so that they will not affect the temperature of the room. These motors are connected with the machines by means of shafts which are provided with a flexible section to prevent any vibrations from the motor being transmitted to the lapping machine.

The Finished Gages

After the gages are finished, they are covered with grease to prevent any corrosion or pitting of the surfaces during storage. A great many of the gages, before being placed on the market, are sent to the Bureau of Standards where they are again carefully tested and certified. Each of these gages is certified by the Bureau of Standards to be within the limits previously mentioned and most of the gages have even smaller inaccuracies. A section of the safe used for storing these certified gages is shown in Fig. 26 which illustrates how the sets are made up. Gages of the same size are grouped together in drawers, which are plainly marked so that it is convenient to make up the different sets. Another view in the department where finished gages are stored is shown in Fig. 27.

The numbers of blocks in the sets of Hoke gages based on the English system of measurement vary from five to eighty-five. The set containing eighty-one blocks is composed of the following sizes: 9 blocks ranging from 0.100 to 0.1009 inch, varying by an increment of 0.0001 inch; 49 blocks ranging from 0.101 to 0.149 inch, varying by an increment of 0.001 inch; 19 blocks ranging from 0.050 to 0.950 inch, varying by an increment of 0.050 inch; and 4 blocks ranging from 1 to 4 inches in length, varying by an increment of 1 inch. With this set all dimensions from 0.200 to over 10 inches, varying by 0.0001 inch, can be obtained, or, in other words it is possible by combining the blocks, to secure over 100,000 different gage sizes.

While all references in this article have been to the Hoke gages, the lapping and optical testing methods previously described are also applied in manufacturing "mike-checks," toolmaker's flats, and all other precision work requiring extremely accurate flat surfaces.

* * *

In the case of an employe who was found in a semi-conscious condition in the wash-room of a factory and who died nearly two weeks later, due, in the opinion of the physician, to brain concussion caused by accident, the Pennsylvania Workmen's Compensation Board ruled that although there were no witnesses nor information as to the nature of the accident, the occurrence of such an accident could be reasonably inferred, and an award should be granted.

JAPANNING METAL ARTICLES

Baking japan, as ordinarily used in manufacturing, consists of two elements, the base and the solvent. The base is usually some variety of asphalt, combined with linseed, or some similar oil, the whole making a hard substance of similar appearance to rubber. This must be liquefied for use, and the common practice is to dissolve it in naphtha or kerosene. The process of japanning various metal articles consists in dipping them in the liquid japan, and then baking them in an oven.

Owing to the volatile and inflammable type of the solvents used, this baking process is somewhat hazardous. After several bakings, the atmosphere in the oven resembles that of the inside of a gasoline engine cylinder, only needing a spark, or even excessively high temperature, to cause an explosion of great force. Occasionally these explosions have been disastrous to human life and have caused fires. This risk has been great enough to cause some of our large municipalities to consider requiring a manufacturer not only to isolate his oven buildings, but also to provide further protection in the form of a fire wall. It also seemed likely that the insurance companies might become interested to the extent of causing increased expenditures on the part of manufacturers who are large users of japan.

The manufacturers consequently became interested in the possibility of developing a type of japan which has a non-combustible solvent. The Research Laboratory of the General Electric Co. was requested to try to find such a product, and the research thus inaugurated resulted in the development of a variety of japan which eliminated the necessity of a solvent possessed of the destructive qualities of the usual kinds. This water japan, as it is called, is an emulsion of the asphalt oil base with water, in which infinitesimal particles of the base are held in suspension in the water instead of being dissolved in it. It was found that this japan had no tendency to settle, even after months of storage, and that, owing to its being suspended in water, losses by evaporation were practically negligible.

The methods of applying the japan are two in number—the electric dip, and the hot dip. The former is appropriate for small articles, and consists in placing them, charged positively, in a negatively charged iron tank of japan. The result is that an even, smooth coating of japan is deposited on the articles, and, since the japan is deposited free from solvent, there is no resultant drip when the lot is conveyed to the baking ovens.

The second method, or the hot dip, which is applicable to large pieces of metal, was found more or less by chance. It had been the custom in the laboratory to preheat the metal before dipping, in order to free it from dirt and grease. This preheating evidently had the same effect of causing the japan to form a deposit on the metal as giving it a positive electrical charge. A third method is also sometimes used which is a combination of the two already mentioned.

The result has been that a kind of japan has been evolved that gives exactly the same effects as the solvent variety. It is cleaner to handle, owing to the absence of drip, and eliminates the danger from explosions and disastrous fires that were such a dangerous feature of the old form.

* * *

The Bureau of Foreign and Domestic Commerce has just issued a booklet on training for foreign trade for the use of those conducting classes in foreign trade in educational institutions and business houses. It will also serve as a guide to business men in their private reading and research. This publication is a manual containing references to textbooks and to sources of general and specific information. Copies can be obtained from the Superintendent of Documents, Washington, D. C., or from any of the district offices of the Bureau of Foreign and Domestic Commerce.

The British Machine Tool Industry

Letter from MACHINERY'S London Correspondent

MACHINE tool builders in Great Britain are without exception busy, machines used for repetition work and in the motor car industry being particularly in demand. Moreover, the new projects will result in the installation of much new equipment in the near future, which applies also to the considerable number of works undergoing extension. Normal activity is increased by the attempt to make up for the time lost on account of the prolonged molders' strike, now settled. While this strike hampered finished production, it proved a blessing in disguise to many firms by affording an opportunity of carrying out a much needed rearrangement of plants. Others, again, had accumulated large stocks of castings and at the termination of the strike had only just begun to feel the effects. In a large number of cases activity was concentrated on accumulating stocks of finished steel parts—some firms indeed going so far as to employ molders in the machine shop with a view to keeping the men together. The inflow of castings will probably involve arrangements being made to increase the machinery capacity, to restore the balance of production. At the end, the strike had begun seriously to affect employment in the engineering trades, the Leeds district in particular suffering in this respect, and in the reduction of time worked, which in cases amounted to as much as three days per week; but in the machine tool industry, for the reasons given, employment was not seriously affected. Makers of heavy machine tools also report that their works are busy. Delivery seems to be the chief consideration, price, within limits, being of less moment. The deliveries of some of the larger makers are gradually improving, and in the case of concerns specializing on one type of machine, seven to ten weeks is offered.

Prices of Machine Tools

Prices show an upward tendency, due to increased cost of castings and freight rates, and a general advance of approximately 10 per cent is freely talked of. The price of castings, for instance, in the Halifax district, has advanced from 3s to 6s per hundredweight. The new railway rates will affect more especially makers of small tools, to whom, should the new rates be insisted on, it will mean an increase in cost of 5 per cent. Small tools are usually made at a low price and are very generally despatched by express.

With regard to imported American tools, the low rate of exchange may eventually have a retarding influence on imports. The increase in cost to an English buyer from this cause alone is in the neighborhood of 30 per cent. The fluctuating value of the pound renders quotations difficult—they have always to be made with the reservation "subject to." For the present, however, the demand for American machines is maintained because of the better deliveries that are possible by dealers who can supply from stock.

Swedish Machine Tools Offered in Great Britain

Swedish machine tool makers are beginning a selling campaign in this country. Prior to the war the whole of the Swedish output was absorbed by the Scandinavian countries, Finland, and Russia, but owing to the prevailing conditions in the two latter countries, this outlet no longer exists. An extensive range of machines can be offered from stock, equal in reliability—it is claimed—to the British product, although produced on a quantity basis as in the United States. Furthermore, the Swedish exchange is within 2 per cent of normal and has remained practically constant for the last six months. The export organization handling these machines, which is called the Swedish Machine Tool Makers Export Co., Ltd., follows the lines of our own Associated British Machine Tool Makers, Ltd., in that the constituent firms have come to an agreement among themselves regarding the particular types of machine each should build, and to unify the separate sales departments in joint sales offices. It is not, therefore, a dealer or agency but a part of the constituent works from which the prices and terms are quoted directly. It is yet too early to gage the extent of this competition; no offices appear to have been taken, the present representation apparently being conducted from a residential address.

Little, so far, is heard of German competition in this country, and the hand of the association is still strong upon its members against handling German productions. German salesmen, however, are in the country, and in one case at least, business has been done in plate frame punching and shearing machines. An item of news which may not yet have reached the United States is to the effect that the Export and Import Section of the German Machine Tool Association provides that no machine tools shall be sold for export from Germany at less than seven times the pre-war price, except to countries allied to Germany during the war, in which case it is to be four times the peace price.

New Developments in Machine Tools

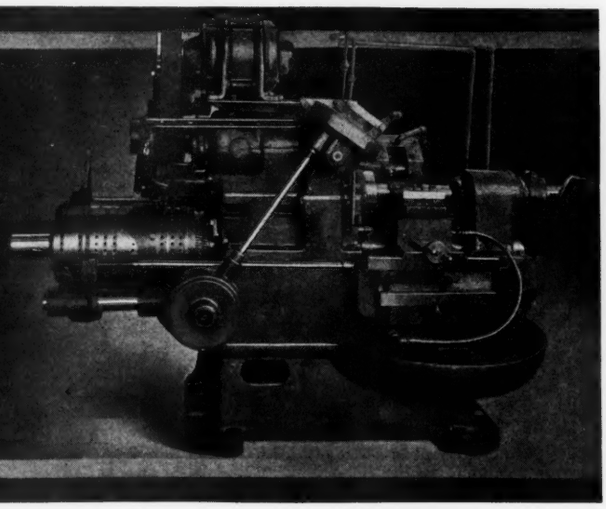
Two Birmingham firms, the Precision Gage Co., and Parsons & Ward have entered the machine tool field; both are placing on the market full screw-cutting engine lathes, of 12 and 15 inches swing, respectively. A new line of plain grinding machines embodying several patented features is being developed by Wadkin, Mills & Co., Nottingham, who are planning to produce these on interchangeable lines in batches of fifty at a time. John Hands & Sons, Birmingham, are introducing a patent power press for manufacturing seamless drawn radiator frame parts. A machine which promises well is an oxy-acetylene blowpipe adapted to a pedestal type of machine-tool frame with positive means for moving the blowpipe in any direction. This tool is introduced by the Godfrey Engineering Co., Wood Green, who has taken up the manufacture in a thoroughgoing manner. A number of the leading plants are engaged in developing new designs or models for the exhibition which is to be held late in the year at Olympia by the Machine Tool Association. This exhibition promises to be a most successful one, as already the main hall and practically the whole of the gallery has been let. Exhibitors are taking the matter very seriously, and are putting up their best efforts so that not a few surprises may be expected.

Small Tools

Jones & Shipman, Leicester, continue to develop their lines of small tools, which in finish closely resemble American products. They are of high quality and sell at a lower figure than American tools. The latest addition is an all-steel drill chuck, made in five parts, which will take drills up to ½ inch in diameter. It appears to be a very serviceable tool and is being produced on the best manufacturing lines. The firm reports a heavy demand for its product in Canada. Another concern, which specializes in twist drills, reports the receipt of many orders for these in America. The plant in question promises in the course of a few months to be the largest in the country.

Machining Automobile Engine Pistons

By RALPH E. FLANDERS
Manager, Jones & Lamson Machine Co., Springfield, Vt.



A Description of the Methods and Tooling Equipments Used in Quantity Production of Automobile Engine Pistons

THE following article contains a description of the various methods used in the quantity production of automobile engine pistons. It deals, however, especially with the tooling equipments used in the various turning, facing, boring, and grooving operations performed on Fay automatic lathes. The simple tooling used on these machines, the small number of separate operations required on the piston by their use, and the automatic performance of the tools, which enables unskilled workmen to be employed for operating these machines, permit the pistons to be machined at a very low labor cost. Although the article describes the machining of only one type of piston, differently designed pistons such as those having domed, beveled, or concaved heads, can also be finished on these machines. In such cases, however, other tooling arrangements must be substituted for the ones employed in the machining of the piston dealt with.

First Machining Operation on the Piston Casting

The first operation performed on the piston casting consists of drilling a center in a boss cast on the outside of the closed end especially for this purpose, in order to permit the casting to be mounted on the centers of the automatic lathes in succeeding operations. This boss should be amply large, so that a deep heavy center can be used on these machines, as a number of cuts are taken at one time and a small center would not prove adequate for the purpose. This centering operation is performed on a drilling machine of the sensitive type, the rough casting being placed over a centering mandrel. By means of this mandrel, the center is drilled true with the rough cored hole in the piston. The combination centering drill and countersink is guided into the work by means of a special bushing.

Roughing Operations

The second operation consists of taking rough cuts over all of the exterior surfaces of the work; this operation is performed on a Fay automatic lathe, as illustrated in Fig. 1. This illustration also shows the set-up of the tooling equipment used in this operation. The piston is mounted on the machine as shown. The work is first slipped over the air-operated expanding and centering mandrel *A*, which is attached to the faceplate of the machine, until stop *B* comes in contact with a small rib on the inside of the wall at the closed end. The piston is centered on the mandrel as the three pins *C* are forced radially outward against the cored hole in the piston by the taper surfaces on push-rod *D*. This occurs when the push-rod is forced toward the tailstock by means of a compressed air cylinder. The ends of pins *C* in contact with the taper surfaces of the push-rod are machined to the same angle as the taper surfaces on the push-rod. When push-rod *D* is returned to its original position, pins *C* are forced back toward the center of the mandrel by means of flat springs attached to the outside of body *A*, which operate upon the outer ends of the pins.

The closed end of the piston is supported by the rotating center *E*, held in an air-operated tailstock, which fits into the center drilled in the preceding operation. The tailstock center is provided with a ball bearing to take up the thrust produced on it. A good view of the air-operated tailstock may be obtained by referring to Fig. 4, which is a top view of the machine used in this operation, taken from the tailstock end. The end of mandrel *A*, Fig. 1, is provided with lugs *F* which come in contact with the bosses provided for the wrist-pin holes, thus causing the piston to rotate as mandrel *A* revolves. By the means just described, the work is well supported, and well driven by a fast air-operated mechanism, one valve operating both push-rod *D* and the tailstock center.

In the operation performed on this machine, surface *G* is rough-faced by tool *H*, grooves *I* are rough-turned by tools *J*,

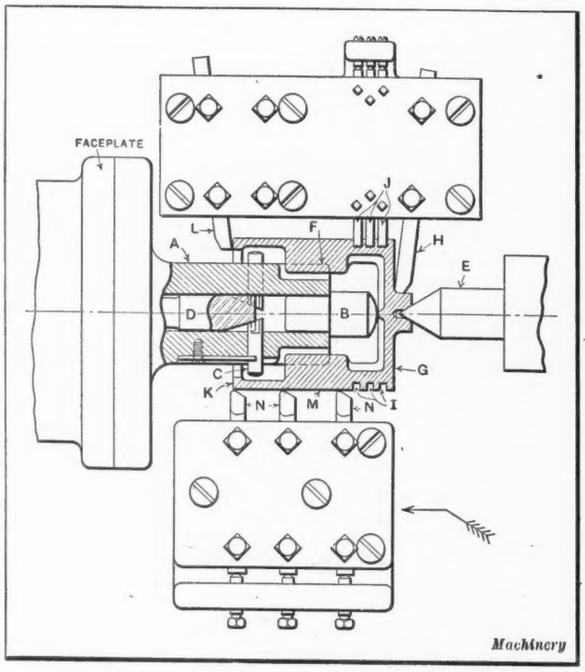


Fig. 1. Tooling Equipment employed in taking Roughing Cuts on Exterior Surfaces of Piston

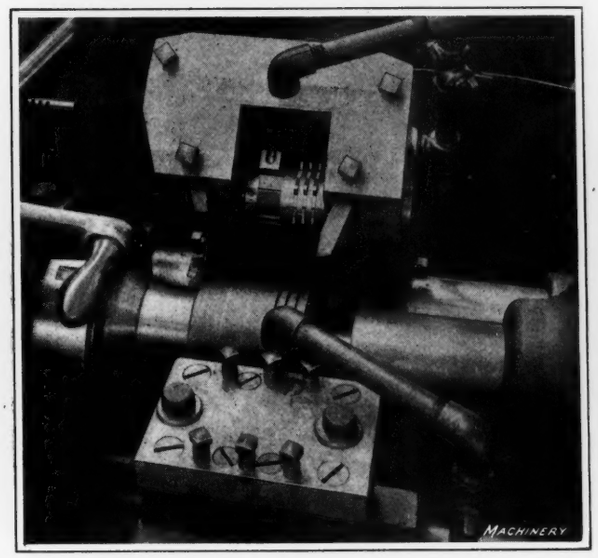


Fig. 2. Machine provided with Circular Cutter for machining the Piston-ring Grooves

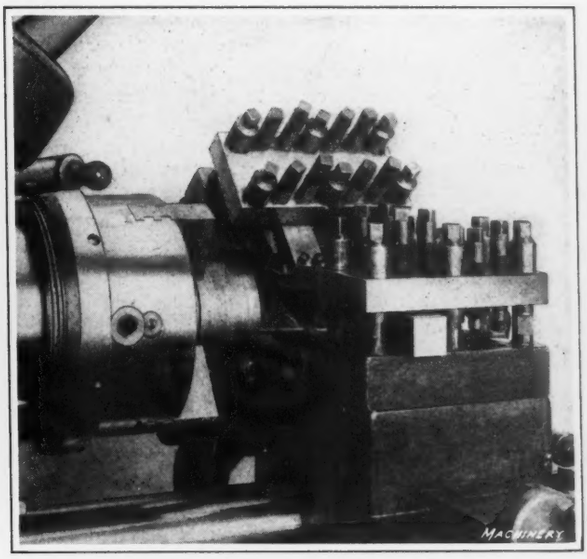


Fig. 3. Set-up of Machine used to take Roughing and Finishing Cuts on Open End of Piston

and surface *K* is rough-faced by tool *L*, all of these tools being mounted on the rear tool-holder. This tool-holder swivels on a round bar at the rear of the machine, and the cuts are taken as the tool-holder is swiveled toward the work; at the same time surface *M* is rough-turned by tools *N*, which are mounted on the carriage at the front of the machine. The carriage is fed toward the work at an angle until the tools take the proper depth of cut, after which it is traversed longitudinally toward the left. The arrow indicates the direction of the carriage traverse. Three tools *N* are provided so that surface *M* can be machined in the same time as surface *G* is rough-faced by tool *H*. Thus, it is apparent that all of the exterior surfaces of the piston are rough-finished in the time consumed in rough-facing surface *G*.

Fig. 2 shows a front view of the tooling equipment on the machine shown in Fig. 4. This equipment is similar to that shown in Fig. 1, the only difference being in the rear tool-holder and the tools employed in producing the three piston-ring grooves. On the machine shown in Fig. 2, a circular tool is used instead of the ordinary tools shown in Fig. 1. This circular tool is ground so as to have six cutting edges equally spaced around its periphery. Any of these cutting edges can be held in the proper cutting position by means of a screw which extends through the rear tool-holder. A locking block is attached to the inner end of this screw, which may be placed in position on any of the steps machined on the lelft-hand end of the cutter, thus preventing the cutter from turning. When desiring to use a new cutting edge, it is only necessary to loosen the screw, thus releasing the locking block, turn the cutter a fraction of a revolution, and then tighten the locking screw again. The advantage of the circular cutter over the tool shown in Fig. 1 is that when the cutting edges become dull, new edges can be readily had without the necessity of the machine being idle while the tools are being reground. One man can operate two machines performing this operation when the production requirements necessitate it.

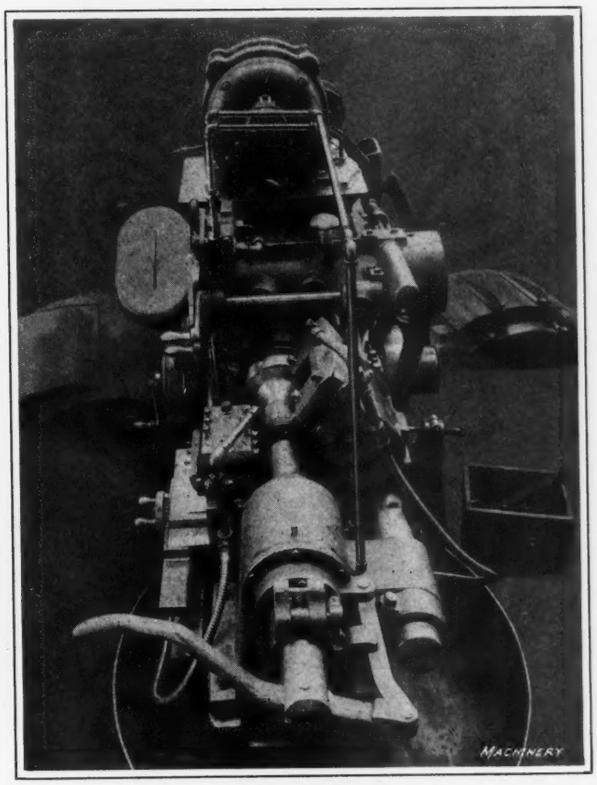


Fig. 4. Top View of Machine shown in Fig. 2, equipped with an Air-operated Tailstock

Drilling the Wrist-pin Holes and Annealing the Piston

The third operation consists of rough-drilling wrist-pin holes *T*, Fig. 5, on a drilling machine. The work is placed in a jig for the performance of this operation, being centered by means of surface *M* and located longitudinally by means of surface *G*. The correct point on the periphery of the piston is brought into the proper position for the operation, by means of the bosses on the inside of the piston through which the wrist-pin holes are drilled. This operation completes the removal of the bulk of the excess material and the scale, and the piston is then ready for annealing.

In the fourth operation, the piston is annealed in order to eliminate all the strains in the metal produced in the preceding operations, and to remove all chances of distortion in succeeding operations. This is the logical time for the annealing operation, because all but one of the roughing cuts have been taken, and so there is not much more metal to be removed from the casting. A modern continuous-feeding automatic furnace was installed in the machine shop so that the rapid production would not be interfered with by the necessity of transporting the work to an outside heat-treating shop. Suitable heat insulation and forced ventilation are provided in order to make the arrangement comfortable even in hot weather.

Finish-facing, and Rough- and Finish-boring Operations on the Open End

Hole *S*, Fig. 5, and surface *K* on the open end of the piston are rough-bored and finish-bored, and finish-faced,

respectively, in the fifth operation, which is performed on a Fay automatic lathe. It may appear to the readers that it would have been better to have machined this end prior to the second operation in order to obtain a finished surface for locating the work on the machine in that operation. However, if these surfaces had been machined at that time, they would have become distorted in seasoning. Because the piston is annealed previous to the machining of this end, there is no danger of further distortion resulting from this operation.

The piston is mounted on the machine as shown in Fig. 5, for the performance of this operation, being held in an air-operated chuck by means of jaws which grip the piston along the previously rough-finished surface *M*. Surface *G* of the work is used to locate the work longitudinally in the chuck. Since these surfaces were machined approximately true with the cored hole in the piston, it is obvious that the surfaces machined in this operation will also be approximately true with the cored hole, because the piston is mounted and located in the chuck by means of surfaces *G* and *M*. This being the case, surfaces *K* and *S* can be used in locating the work in future operations. It will be seen by referring to the illustration that the open end of the piston projects well beyond the chuck jaws, and on this account no distortion results from this chucking.

The following is the manner in which the various surfaces are finished. The rear tool-holder first moves longitudinally along the bar on which it is mounted, and hole *S* in the open end of the piston is rough-bored by tool *O*. It then swivels toward the center of the machine, during which movement surface *K* is finish-faced by tool *P*. This surface was rough-faced in the second operation. The arrow indicates the feeding movements of the rear tool-holder. In the front carriage is held tool *Q* which finish-bores hole *S* as the carriage is fed in a longitudinal direction. When it is desired to bevel the outer end of this hole, another tool can be mounted on the front carriage for the performance of this operation, in the position indicated by the dot-and-dash lines *R*. At the conclusion of the operation, the carriage and the rear tool-holder are withdrawn far enough from the work to permit its easy removal from the machine. The tools are withdrawn in such a manner that they do not score the work. Fig. 3 shows a machine provided with the tooling equipment required for this operation.

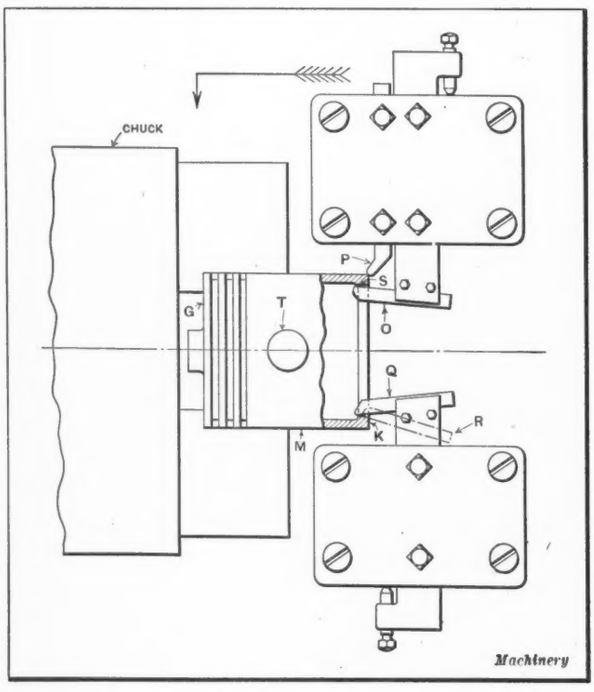


Fig. 5. Lay-out of Tooling Equipment provided on Machine employed to finish the Open End of the Piston

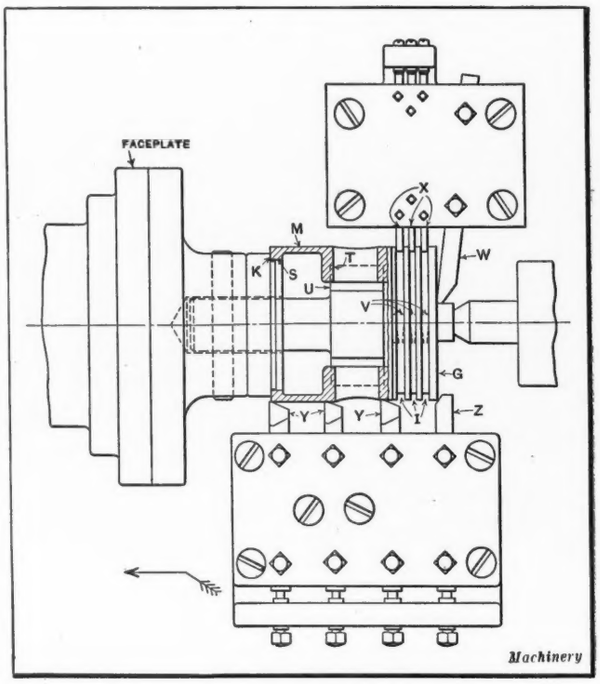


Fig. 6. Tooling Equipment required in taking the Finishing Cuts on the Exterior Surfaces of the Piston

Finishing Operations Performed on External Surfaces

For the performance of the sixth operation, the work mounted on another Fay automatic lathe as shown in Fig. 6. This operation consists of finish-facing surface *G*, finish-turning surface *M*, and finish-turning grooves *I*. The work is mounted on the machine by means of a hardened and ground plate which is attached to the faceplate of the lathe. The piston is seated on this plate by means of hole *S*, and is located longitudinally by surface *K*. The closed end of the work is supported by a floating center, held in a quick-acting air-operated tailstock. This center is made floating so as to permit it to adjust itself to the position of the center in the boss on the closed end of the piston, which is controlled by the seating of hole *S* on the hardened and ground plate previously mentioned. Otherwise, it would have been necessary to recenter the piston at this end. This method of mounting the work has proved as accurate as the method of holding the work in place by means of a push-rod projecting into the cored hole and attached to a pin placed in the wrist-pin holes. It also avoids a loose piece, and is more rapidly operated. The work is rotated by means of lugs on driver *U*, which engage with the wrist-pin bosses on the inside of the piston. The tailstock center is provided with a ball bearing to take up the thrust.

Three tool-holders are provided for holding the tools used in this operation. The front carriage and rear tool-holder are equipped somewhat similarly to those shown in Fig. 1, but there is another attachment underneath the piston which carries tools *V*. These tools are employed to take a second roughing cut on the piston-ring grooves *I*. The attachment is supported by the tailstock casting, and is operated from the carriage. Surface *G* is finish-faced by tool *W*, and grooves *I* are finish-turned by tools *X*. These tools are mounted on the rear tool-holder and are brought into the cutting position when the tool-holder is swiveled toward the center of the machine. Surface *M* is finish-turned by tools *Y*, which are held on the front carriage, and a bevel is turned on the outer edge of surface *G* by tool *Z*, which is also mounted on the front carriage. All of the tools used in this operation are fed toward or across the work at the same time, so that the entire operation is completed in the time consumed by tool *W* in facing surface *G*. The direction of the carriage movement in this operation is indicated by the arrow. The machine shown in Fig. 7 is provided with

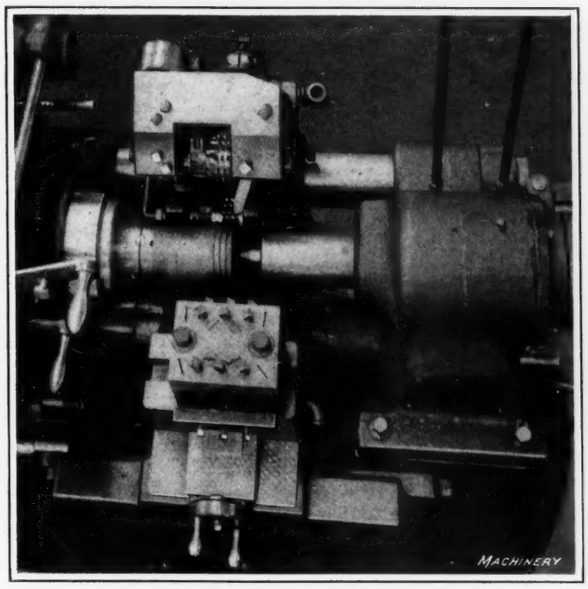


Fig. 7. Machine equipped with Tools required in the Final Lathe Operation

the tooling equipment required for this finishing operation. Because the piston-ring grooves are given two roughing cuts and one finishing cut, great accuracy is obtained in the finished piston. Also because the grooves are finished while the work is placed on centers on which there is no end play, it is unnecessary to perform a final grooving operation on an engine lathe in order to obtain a perfect gas seal when the piston is placed in the automobile cylinder. An operator can readily handle two machines engaged in the performance of this operation.

Final Operations on the Piston

The seventh operation consists of finishing the wrist-pin holes which are rough-drilled in the third operation. The eighth operation is performed on a drilling machine and consists of drilling a number of small holes which are used for oiling purposes, etc. In the ninth operation, the center boss on the outside of the closed end of the piston is sawed off in a hand milling machine, and the rough surface left by this operation is finished on a disk grinding machine. The boss could be entirely removed on the grinding machine if desired. The final operation on the piston consists of grinding surface *M* and polishing surface *G*. The piston is secured to the faceplate of the grinding machine in this operation by means of a draw-rod which projects into the cored hole and is attached to a pin inserted in the wrist-pin holes.

The Fay automatic lathes used in three of the operations described are started by an operator, but are stopped automatically at the completion of the operation by means of a quick-acting brake. On work requiring less accuracy, the operations performed on machines of this type could be somewhat simplified and could be performed a trifle more rapidly.

* * *

An investigation of fatigue phenomena in metals under repeated stress has just been started under the joint auspices of the National Research Council, the Engineering Foundation, and the Engineering Experiment Station of the University of Illinois. The Engineering Foundation is providing $15,000 a year for two years for this investigation, and the Engineering Division of the National Research Council is acting in an advisory capacity, largely through its committee on Fatigue Phenomena in Metals. The experimental work is being done in the laboratories of the Engineering Experiment Station of the University of Illinois under the immediate direction of Professor H. F. Moore, research professor of engineering materials and chairman of the committee mentioned.

WHAT IS ENGINEERING?

The Committee on Development of the American Society of Civil Engineers, in its report to the board of directors presented on October 14, submitted the following definitions of engineering:

1. Engineering is the science and art of directing the great sources of power in Nature to the use and convenience of man.

2. Engineering is an art and a science. It is a science in so far as physical laws are its base, and an art in so far as in the application of these laws the things designed and constructed develop the spirit of progress, the creation of wealth, and the well-being of all peoples. Engineering is generally divided into four major divisions: civil, mechanical, electrical, and mining. The practice of engineering requires knowledge of physical laws, forces, and the materials of Nature. The professional engineer is one who by reason of special training, education, and experience is qualified to design and direct the construction of engineering work in one or more of the major divisions of engineering.

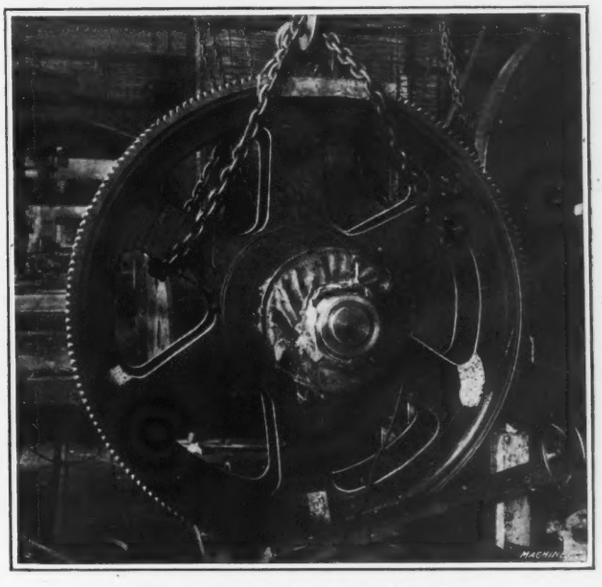
3. Engineering is the creative science and art of applying economically the materials and forces of Nature to the use and convenience of man.

4. Engineering is the science of industrial effort, and the science and art of applying this effort for the welfare of the public. An engineer is one versed in the science and art of industrial effort made for the purpose of public welfare.

* * *

REPAIR MADE ON TURBINE GEAR BY ARC WELDING

The accompanying illustration shows a cast-steel herringbone turbine gear valued at between $7000 and $8000 which was saved from the scrap heap by the "Weldcraft" process of arc welding. This gear, which is part of the equipment of the steamship *Belfort*, is 8½ feet in diameter, has a 24-inch face, weighs approximately 8 tons, and is of double-flange double-spoke construction. This gear was first welded by the ordinary arc-welding process, and broke in the weld. In making the repair, the Electric Welding Co. of America found it necessary to cut out all the welding material that had previously been deposited. This accounts for the unusual width of the welds. It may be interesting to note that this weld was made without preheating. Electric arc welding is becoming of ever-increasing importance in repair work of all kinds, and provides a means for saving many expensive castings as well as the time required for replacement.



Turbine Gear repaired by Arc-welding Process

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THE AGE OF PRECISION

This is the age of the automobile, the flying machine, of electricity, of the turbine-driven ship, and a dozen other important engineering or industrial developments—according to the particular interests and activities of the individual. But the present era in the machine-building and tool-manufacturing fields cannot be defined more accurately than by calling it the Age of Precision. The standards of precision in mechanical work have changed so radically in the last few years that we may well say we have entered upon a new era in this respect. Not more than twenty years ago work that was accurate within one-thousandth of an inch was considered precision work of high character. Ten years ago mechanical men began to speak more frequently of a ten-thousandth inch, and today we are beginning to talk about hundred-thousandths and millionths. Although we all know that mechanical work in general is not produced with any such precision as these small fractions indicate, the fact remains that means are now available for measuring in these terms when it becomes necessary.

The precision gage-blocks which have been developed to the highest accuracy, enabled the mechanical industries, more than any other factor, to attain the present wonderful precision limits. The methods employed in the production of these gages have been surrounded with great secrecy until recently, and it is with considerable satisfaction that MACHINERY publishes, as the leading article in this number, the first complete and detailed account of the methods used in making precision gage-blocks on a commercial basis.

This article on "How Precision Gage-blocks Are Made" will arouse interest wherever mechanical men are found, the world over; for nothing interests them more than an exposition of the ingenious methods whereby such remarkable accuracy is attained.

* * *

A SUBSTITUTE FOR APPRENTICESHIP

Before the departmental method of factory administration came into general use it was usual for boys who wished to become machinists to serve a four-year apprenticeship and thus acquire a comprehensive knowledge of their trade. But this is unfortunately not as common a practice today, although there is still a general demand for the "all-around" mechanic. In fact, the present tendency for boys to avoid signing an apprenticeship agreement has created a scarcity of thoroughly trained mechanics which has placed a premium upon their services. It is difficult now to get boys to become apprentices, because a few weeks of training gives them sufficient knowledge of some specific machining operation to earn what appears to be a satisfactory wage to those who are just entering upon their life's work in the machine shop. Consequently, they are unwilling to agree to spend four years in receiving a thorough training, during which their rate of pay will be only nominal.

One plan for the development of well-trained mechanics that is giving satisfactory results is used at the Willys-Overland plant in Toledo. The features of this plan are fully discussed in an article entitled "Successful Substitute for Apprenticeship" that appears elsewhere in this number. It is explained in this article that the system comprises three distinct functions, but at present we are concerned only with the way in which it serves as a substitute for apprenticeship. A training shop is provided with facilities for teaching one specific machining operation to untrained men; but it does not stop there. Any employe desiring to acquire experience in other operations can obtain a transfer to the training shop for that purpose and while being trained, is paid at a rate 10 per cent lower than the price placed on his labor in a production department where he is familiar with all details of the work. As more than two weeks' training for a new job is seldom required, the loss resulting from the 10 per cent reduction in pay is small.

When a number of applications are received for training in the same kind of work, preference is given to applicants employed on the class of work most nearly allied to the one in which training is desired. This saves time in the training and also provides an incentive for men to gain a thorough knowledge of the machinist's trade, because they are likely to receive preliminary training for a simple job and then return to the training school repeatedly to acquire experience on more skilled work for which they will receive a higher rate of pay. From the employer's viewpoint, this system of training affords a reasonably satisfactory substitute for the regular system of apprenticeship.

* * *

HEAVIER MACHINE TOOLS REQUIRED

During the last fifteen years the weight and size of machine tools of all types have continually increased, the increase having been caused originally by the introduction of high-speed steel. But some users of machine tools still complain that they are not heavy enough to utilize high-speed steel cutting tools to their greatest capacity. Recently a manufacturer of a special product built a machine for his own use in which he incorporated ideas as to weight and size which he had found from experience were applicable to his work, and was able to take from two to three times as heavy cuts as are possible with standard machine tools of the same type. It is doubtful if machine tools as heavy as this would be used generally, because in many instances the standard machines are not required to work to their full capacity, but take cuts for which a lighter machine is adequate. There is considerable demand, however, for very heavy machine tools, especially adapted for heavy, interchangeable manufacture, and it is probable that the future weights and sizes of some standard machine tools will be further increased. The new steels, of which we have recently heard, are said to possess a far greater cutting capacity than the present high-speed steels and may also influence future developments in the direction referred to.

Inches versus Millimeters

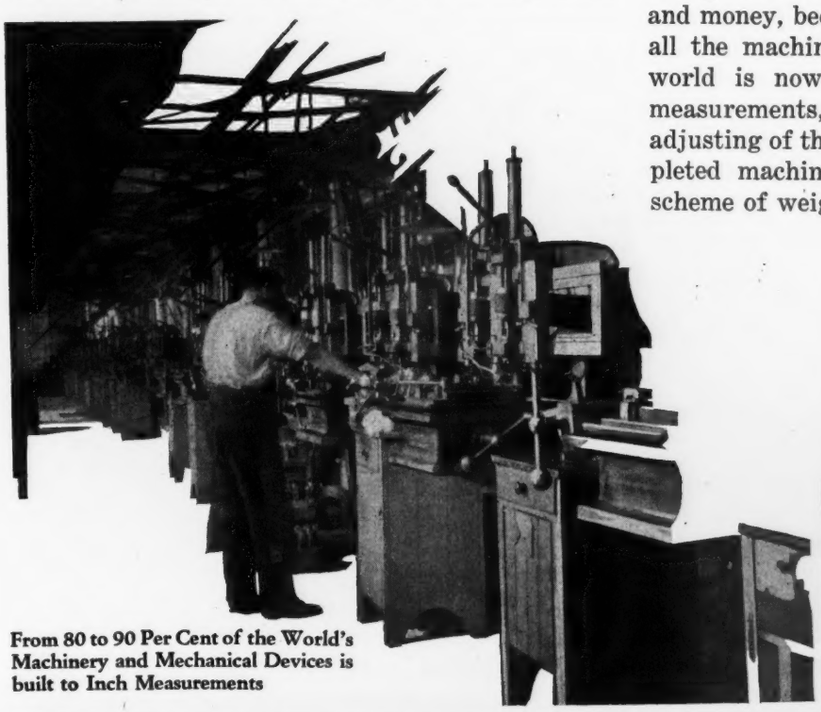
THE controversy between the advocates of the metric system and those who believe that our present system of weights and measures should be retained has apparently passed the academic stage, and the believers in the metric system are now trying to induce Congress to pass laws making the use of that system compulsory in the United States.

MACHINERY has given comparatively little space to this controversy in the past, for as long as it was merely a matter of argument, no practical purpose was served by a rethreshing of opinions. Now, however, the situation has changed, and it appears that great injury may result if Congress is hurried into taking definite action on this question without affording the engineers and manufacturers of the country the fullest opportunity to be heard.

A change in the system of weights and measures is not a question for Congress to decide without hearing the opinions of manufacturers who are vitally interested. Members of Congress, however able, lack the special, practical experience required to pass upon a question of such moment to our industries. The system of measurement used in engineering and industrial work is so closely interwoven with our whole manufacturing and mechanical progress that only engineers and manufacturers possess the definite knowledge, practical experience and judgment to forecast the effect of so profound a change. If the various associations of manufacturers and the engineering societies of the country decide that a change to the metric system is advisable, then these bodies will undoubtedly cooperate to bring it about through the agency of the newly established Engineering Standards Committee.

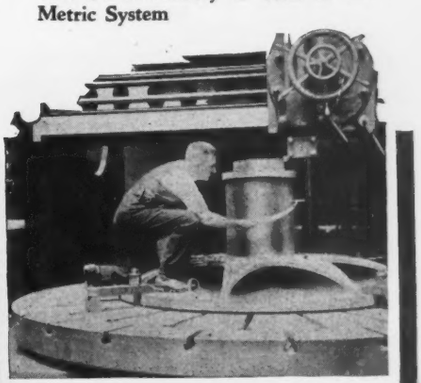
The main question to consider is whether with the present advanced development of our industries, we can afford to make a change. If it is the judgment of a majority of those connected with our manufacturing and engineering interests that it would involve so much confusion and loss and would develop such mechanical difficulties as to completely overshadow any possible gain, then their judgment should prevail. When our manufacturers and engineers can see that the proposed change will benefit those who use their products or increase their sales in countries using the metric system, they will need no urging to adopt it.

Probably the best service MACHINERY can render its readers at this juncture is to place on record the opinions of some of the leading manufacturers and engineers in the machine-building field, and some of these will be found in this number. Their opinions are unanimously for the retention of the present system of measurement. They believe that a change would cause great confusion and loss of time and money, because between 80 and 90 per cent of all the machinery and mechanical devices in the world is now made to the English system of measurements, and a change would necessitate the adjusting of this enormous quantity of already completed machinery and mechanisms into the new scheme of weights and measures.



From 80 to 90 Per Cent of the World's Machinery and Mechanical Devices is built to Inch Measurements

Only from 10 to 20 Per Cent of the World's Machinery is built to the Metric System



What a Change of Measures Would Mean

By JAMES HARTNESS, President, Jones & Lamson Machine Co., Springfield, Vt.
Past President, American Society of Mechanical Engineers

THERE are many reasons why the scientific man should prefer the metric system of measurements, because, being based on the decimal notation, it simplifies scientific and advanced engineering computations. On the face of it, the system is simple and the correlation of the units of weights and the measures for lengths, areas, and volumes unquestionably presents an advantage. In considering the question whether the English system of measurements should be replaced by the metric system, the scientific man however, must, not think only of himself, but he must try to base his judgment upon a broad view of the requirements of the whole scientific, engineering, and industrial world.

In dealing with this subject, I prefer to divide the useful members of the community into two broad groups, which, for simplicity of expression, may be called *word-men* and *work-men*. In the group of word-men I include all those whose usefulness mainly consists in the ideas that they convey to others by the spoken or written word. Hence, this group includes scientists, industrial leaders, designing engineers, the guiding and superintending forces in our industries, as well as the administrative officers of the political state and the law-makers. By work-men is meant that large group which is directly engaged in the actual production of useful things—things necessary for the health, happiness, and comfort of the community—and who perform this work by direct or indirect application of manual effort.

At the bottom of the whole discussion of weights and measures is the understanding on the part of the word-man of the problems that confront the work-man. It must be admitted from the outset that the worker—the actual producer of things—is the most essential man in the world, for without him the work of all others comes to naught. Other members in the community are essential only in the degree to which they cooperate with and aid the producer or work-man in making his efforts more efficient. On the other hand, the directing force in the world is that of the word-man, and to understand the importance of the question of weights and measures, the scientific man must try to obtain the work-man's point of view.

How the Problem Must be Approached

The greatest enemy of a nation in time of war and in time of peace alike is he who misdirects labor, and unfortunately, many have unwittingly been in this class. To make a constructive suggestion with regard to a system of measurements, we must recognize from the start that the man who disagrees with us is undoubtedly imbued with the same sincere purpose toward the welfare of the community at large as we possess. Our contribution toward solving the problem must, therefore, lie mostly in our endeavor to come to a general agreement on the fundamental fact that the work-man's—the producer's—interests must be considered.

The word-man is the natural leader. Often he originally was a work-man who by chance or otherwise has become a leader, and his experience from that point on differs from his experience as a work-man, even though he may not himself realize it. He develops his reasoning facilities, while the work-man develops those powers which enter into the performance of the skilled worker. During this development it becomes quite natural that the word-man should find himself leaning toward the metric system, on account of its apparent simplicity, while the work-man favors the retention of the inch, which possesses some of the elementary principles of simplicity that appeal to the untrained mind.

The greatest problem of the scientist—the word-man—is to obtain a true viewpoint regarding the importance of the work performed by the work-man. Our stumbling block in the past, and our greatest menace at present, lies in the failure of the word-man to understand the work-man. We have reached a point, however, where the relationship of the workers and the leaders must be better understood. In the past, many a time, unfortunately, through a misconception of the workers' attitude, ill-fitting systems of management have been foisted upon the work-man and various blunders have been made that have greatly reduced the efficiency as well as the happiness of the workers. We must be careful that we do not commit a similar error in our consideration of the metric system. Any action on this question should be taken with full recognition of its effects upon production. If a change is made that facilitates the worker's operations, then it is desirable. If it handicaps the worker and reduces the value of the machines and mechanisms already in place in the manufacturing industries and in the hands of mechanics, farmers, etc., it would be harmful.

Basic Facts Guiding Final Decision

The workers who, in the last analysis, produce the things upon which our civilization depends, prefer the old system of measurements because in the binary system it is easier to make the primitive divisions, and they should not be disturbed by imposing on them a new mode of expression.

But why should the worker's preference and convenience be given so much consideration? This question is best answered by considering the fact that the energies of the industrial world are interfered with only by unusual circumstances, such as wars, depressions, or unwise tampering with the systems under which work is performed. The machines and mechanisms produced by labor in the past and which are now in use in every conceivable part of the globe, should remain upon an interchangeable basis as far as possible. If there were an international standard of measurement, it would be preferable; but lacking this, the system to which the greater part of the world's machines and mechanisms have been made must receive most favorable consideration. It is safe to say that of the vast amount of machinery and mechanical devices in the world, from 80 to 90 per cent are made to inch measurements, and only between 10 and 20 per cent to the metric or other systems.

Hence, it is evident that it is essential that the inch should remain the standard length measure in the great machine building industries of the English-speaking world, so as to avoid anything that would handicap the worker or that would depreciate over 80 per cent of the existing machinery.

The difficulty with the men who advocate the metric system is that they do not understand the problems of the industrial world—of the work-man. If there is a misunderstanding of the work-man, however, it is not the scientific man who is to blame, but it is those who are closest to the work by experience and relationship, and this has prompted the writer to say this word for the inch standard. Both a universal language and standard of measure would be desirable. So far as the standard of measure is concerned, there is only one way to solve the problem—by a 40-inch meter.

The place of highest honor in this world should be accorded to those who are beneficial leaders of the worker. Let us all be careful. Let us remember that the worker is the essential man and that we serve well or otherwise as we sense the conditions under which the worker functions.

The Threat of the Metric System

By HENRY D. SHARPE, President and Treasurer, Brown & Sharpe Mfg. Co., Providence, R. I.

In this article, Henry D. Sharpe, the head of one of the leading machine-tool building firms in the United States, points out the reasons why the metric system should not be made compulsory in the United States, calling attention to the importance of uniformity in weights and measures as a national asset and maintaining that such uniformity is insured by retaining the present system, while it would be lost if the metric system were adopted. Mr. Sharpe does not enter into any arguments as to the relative merits of the two systems from a theoretical point of view, but merely points out the practical reasons why at this particular time a radical change in the system of measurements would mean a serious loss to American industries with no corresponding gain.

THE proposal of encouraging a change in the basic standards of weights and measures is a most serious one for any country to contemplate. In the case of a country which has a number of competing systems, such a single system might be embraced with eagerness as well as profit because it would afford relief from complexities long endured. Yet, even here the mere fact of attempted change would be attended with great difficulties. On the other hand, when a country has a substantially uniform system of weights and measures as is enjoyed by the United States, by the British Empire, and by large districts of the world which have traded with these countries for generations, then the project of a change becomes most serious and forbidding.

Facts, Not Theories, Interest the Practical Mechanic

In a mechanical journal one naturally dwells upon the facts of the industry which concern the constituency of the journal itself. The welfare of the mechanical industries prompts a word of warning which cannot be made too strong in the face of suggestions which are persistently and seriously made that the United States should promote, in its usage of weights and measures, a lack of uniformity, after the country has built up its wonderful industrial assets under a system giving substantial uniformity. The encouragement of the metric system means the taking on of a foreign system which cannot possibly supersede, but will inevitably complicate and disturb, the working of a system which we have long been used to.

Practically all American mechanical industries are founded upon the existing system of weights and measures, and these same industries enjoy a real uniformity in the use of such a system. On the other hand, no American mechanical industries of any importance have put out any S. O. S. call for a change in the existing system of weights and measures. While individuals, here and there, some of them connected with great industries, are sometimes sympathetic in a discussion of change, generally speaking, the practical people of our industries almost never speak any words of sympathy—in fact, they are ardently opposed to any change at all. These people know full well the questions which are involved; they know that mechanical practice is inevitably tied to the past because of our system of standardization in manufacture which will prevent the changing of stock parts in every industry where such system has been used.

This American practice of standardization is one of the glories of our industrial development, enabling us to lead the world in much industrial effort; any weakening of its value, such as the promotion of a new system of weights and measures would be the silliest piece of procedure that an intelligent nation could attempt.

Uniformity in Weights and Measures is a National Asset

Uniformity in weights and measures, then, is an invaluable asset to our national industry and must be maintained; there is nothing to promote or to preserve uniformity in encouraging the change which has been proposed. Whether such a change as is seriously proposed would be undertaken by "encouragement," through the passage of a law stipulating that government orders, which are of a large and growing volume in this country, should all be figured in the new system, or by a compulsory law, it would in either case result in confusion and even in a sort of chaotic state in the mechanical industry.

A great many estimates have been made by manufacturers of this country as to the probable cost to a manufacturing business making a change from the existing English system to the metric system by a complete change in fixtures, tools and gages; doubtless these estimates have their value. If manufacturers were to make such changes as these estimates imply, in our opinion the estimates are not exaggerated; yet they do not take account of the handicap placed upon industry following a certain lack of smoothness in running, the certainty of errors in work, and the occurrence of numerous difficulties unforeseen in making such changes.

Our personal opinion, however, is that the favoring of the metric system by Congress, either by "encouragement" or by "compulsion" would not insure a vast majority of concerns attempting to change their tools; for such a change would be altogether too forbidding. Industrial managers, generally, would have to resign themselves to facing a lack of uniformity in weights and measures—to attempt a change would be too difficult and impossible.

We should expect, however, that many new concerns would attempt to use the metric system following the fiat of Congress, which practice in a very short time would produce results of a most troublesome sort to our industries. The effect of such an attempted change upon the people of this country, whose habits of mind and training would be outraged by such government action, would gradually be made evident. As time went on, instead of the substantial uniformity now enjoyed in our industries, a serious lack of uniformity would result. It would be impossible to dislodge from American usage and the American mind the existing system of weights and measures, but the encouragement of the new system would create a dual system making the greatest inconvenience and damage to industry.

Opinions Stated are Based upon Past Experience

The above analysis is based upon attempts to introduce the metric system which have been made by certain shops in time past; bother, confusion, and regret have resulted. Nothing effective has ever been said by the metric enthusiast which will disprove reliable testimony on this subject. The making of metric scales, gages, and other instruments of precision is accomplished in shops using the English system, by using the English system as a basis for measurement. It is all in the day's work and affords no argument in favor of the metric system itself. Where two systems are used in one shop, one system is generally used as the ultimate standard and the other system, if endured, is generally translated into it. With the probable part usage of the new system, owing to government encouragement and

its adoption in some industries by unthinking people, a tax would be placed upon industry in general which would certainly afford a distinct lack of economy in national life.

Without any doubt, this period of growing confusion, owing to the introduction of a system foreign to the habits of our national life, would give this country an education in the errors of Congressional legislation which would make famous, or rather infamous, the people of the present day who had proposed such changes.

To Improve System of Measurements Radical Change is Not Necessary

Let us be fair and admit that the existing system of weights and measures is susceptible to improvement. Without doubt, certain subdivisions of existing units can gradually be done away with by encouragement of a proper sort, if not by the lapse of time. On the other hand, certain new subdivisions of existing units may be introduced; but all this should be done with due regard for the practices of our people, the usages of everyday life, and the thought of the individual. History has shown that changes of this sort are most difficult to make unless they are brought about following the needs of the situation, whatever it may be. Through decades past, American practice and industry have effected improvements of their own in weights and measures. Doubtless, in the years to come organization and need may effect other improvements of importance. The most difficult improvements or changes are in the nomenclature of ordinary life. Can the workman in various industries be induced to make these changes, even should his employer make a serious attempt to teach him? Can the housewife be induced to give up her standards of weight and measure? Can the farmer be educated to yield his standards of purchase and sale? Can the building trades be induced to cast aside names and standards which have been used by them for decades to take over a new nomenclature and standards which mean nothing to them?

The main reasons for opposing the adoption of the metric system are stated by Mr. Sharpe to be the lack of uniformity in weights and measures that would result; the promotion of a system not desired by any considerable number of men in the industries; interference with the habits of thought of the nation; the fact that the metric system is not necessary for successful promotion of foreign trade; and that the practical needs of industry have proved themselves always to be met by the English system.

A great deal has been made of the assumed necessity for the encouragement of the metric system in this country following developments, actual and promised, in foreign trade. Indeed, a report upon this subject has been rendered by the director of the Bureau of Standards in Washington which has achieved wide publicity. The implication of this report is that if the United States is to achieve an added volume of foreign trade it is advisable to make the change in our existing system of weights and measures to the metric system so as to be in harmony with the practices of competing foreign nations. As practical exporters of a large volume of mechanical products whose sale has been the result of intelligent prosecution, we have no hesitation in saying that the implications in this report are misleading and unwarranted.

Summary of Reasons for Opposition to Metric System

We are, accordingly, opposed to the official encouragement or adoption of the metric system for these reasons:

1. It means the promotion of a lack of uniformity in our system of weights and measures, whereas, now the United States enjoys a practical uniformity; such uniformity is one of the assets of American industry.

2. It means the promotion of measures undesired by any considerable number of men in industry whose infliction upon industry as a whole would cause great confusion and waste, and instead of assisting, would greatly hamper us in competition with advanced foreign nations.

3. It means the interference with habits of thought enjoyed by generations among the great mass of our people.

4. It is absolutely unnecessary to the successful promotion of foreign trade; we enjoy a large foreign trade now without the metric system, except where we think it of advantage to use it in our products; its furtherance depends upon the initiation of individuals and not the assumptions of government officials and other theorists.

5. The metric system, while liked by many, has never justified itself as in any way superior to the English system of weights and measures in the practical needs of industry.

6. No better warning against its promotion can be made than by quoting these words of John Quincy Adams in his classic report of weights and measures published one hundred years ago, where he says: "The substitution of an entire new system of weights and measures instead of one long established and in general use, is one of the most arduous exercises of legislative authority. There is, indeed, no difficulty in enacting and promulgating the law, but the difficulties of carrying it into execution are always great and have often proved insuperable. The legislator . . . finishes by increasing the diversities which it was his intention to abolish, and by loading his statute books only with the impotence of authority and the uniformity of confusion."

Concluding Remarks

The agitation for a change in our basic system of weights and measures by force—the force of law—is characteristic of the times. In previous generations the thought running through the minds of our people and its legislators was that government should do the least necessary, and that private industries and private individuals should be untrammeled by government interference of its people trying to live and to get a living. With change of time, however, certain undesirable influences have been evolved which we can easily recognize. Among these influences are the force of organized propaganda, the substitution of the opinion of theory for practice, as the basis of argument of change, whatever it may be, and the growing power of a government bureaucracy.

In the agitation for the metric system, the first influence is exemplified in the conduct of the so-called World Trade Club of San Francisco, an organization which flourishes by virtue of ample and unknown sources of revenue, which issues its advertising matter in editions widely distributed, filled with half truths and misrepresentations.

The second influence is exemplified in the great attention given on this question to the opinions of men of science and theory, instead of listening to the men who conduct the affairs of industry and business in general, these latter having knowledge of theory, it is true, but tempered by the restraint of experience and practice.

Of a third influence—the growing power of government bureaucracy—no better illustration can be given than the influence of years past of the Bureau of Standards in Washington. Without this influence few of the members of Congress would favor the metric system; without this persistent effort to undermine the existing system of weights and measures giving uniformity, the metric system would not have been proclaimed as the basis of the official standards of the government itself.

All of these influences—a widespread propaganda, the recognition of the authority of theory instead of practice, and government bureaucracy—have been the greatest factors in the agitation for the furtherance of the metric system; but the threat of the metric system will not proceed further if the industries and the people of this country can be shown what its enactment would mean.

The English Versus the Metric System

By C. H. NORTON, Chief Engineer, Norton Co., Worcester, Mass.

THE professor and teacher tell us the difference between the metric and inch measure, how beautiful the metric measure is in its arrangement, and how all the different units have so nearly the same name that they all sound alike as they are spoken, whether they refer to solid, liquid, or linear measure. They tell us how easy it is to figure in metric units and how the meter is a certain part of the earth's circumference.

As a boy, without experience, what I read in books and what the teacher said I believed to be not only the simple truth, but the only truth; during that period of life, when experience was unknown, the only knowledge I could obtain was gained from books written by people who obtained their knowledge from reading books that were written by others, who, in turn, had obtained their knowledge from studying books written by others who had obtained their knowledge in the same manner. At that time, when all I knew was taught me by teachers who learned "what had been done and who did it" by studying what others who had written had learned in the same way, I was greatly interested in the very ingenious academic invention known as the metric system and dreamed dreams of the wonders that could be accomplished by its universal adoption.

But, very early in life I was forced by necessity to earn my own living and the living of others. I was passed on from the society of those who knew "what had been done and who did it" to association with those who knew "what to do and how to do it." Contact with these people, who really measured the products of the world, and association with the men who by their initiative and production have made this country what it is and who have placed it at the head of the world in education, art, comfort, and luxury, taught me, as time went on, that the metric system was not as useful to the men who actually measured, as the inch system.

In his discussion of the proposed compulsory adoption of the metric system, Mr. Norton bases his conclusions upon more than fifty years' personal experience in the machine-building field, which leads him to believe that any change undertaken now would be extremely costly and would, in fact, rock the very foundations upon which our industrial structure is built. He emphasizes particularly the fact that the question of measurements is the concern of those who measure the products of the industries and not of those who merely teach others in the study of measurements. He points out the serious consequences of the proposed change and the difficulties that would be encountered.

Those who Use Measurements Know More about them than those who Merely Teach

I have now, during fifty-four years' experience as a mechanic, designer, and engineer, responsible for results, come to know that the men who measure know more about systems of measurement and their usefulness than the men who simply teach measure. In my fifty-four years of dealing with fine measures and calculations to secure the correlation of all the hundreds of thousands of moving elements of machinery, I have come to know that the reason why the metric system has not been adopted in this country is simply because it is not good enough for adoption. If it had been better than the present system, the initiative of the American mechanic would long ago have caused its adoption, and no law could have prevented him from doing so. He always has and always will adopt the system best suited to his success.

To propose the compulsory adoption of it now is an insult to the intelligence and initiative of American mechanical genius. During the fifty years since the metric system was made legal in this country the American mechanic has made all that we have in this country possible, including our institutions of learning, and, therefore, the attitude of a portion of our educators in respect to the metric measure and its proposed compulsory adoption is presumptuous in the extreme.

Practically Impossible to Make a Change Now

It is not because we are all ignoramuses, Mr. Professor, that we do not use the metric measure; it is not that we do not understand the metric measure; it is not that we have not read your books. Whatever the merits or demerits of the system, it is a physical impossibility to compel its use. Moreover, it is now impossible to change, if we would, because such a change would wreck our great industries, built up by so many years of ingenious inventions, and by the work of so many thousands of the best mechanics that the world ever produced.

In a comparatively small organization there are some 400,000 dimensions on many thousand drawings, all used by a thousand workmen who have required years—in fact a lifetime—to learn to read and to understand them. To translate these dimensions into metric, with all the attendant errors, would wreck the business, to say nothing of the task of teaching the thousand workmen to read and apply them.

The Danger of Two Systems Used Simultaneously

Any attempt at compulsion would not stop the use of the English system in the great majority of cases, for the reasons just stated. A few zealots might cause our manufacturers much expense and trouble with the courts for a time, but in the end no change would be made, except that people, starting new industries, would adopt the metric system to avoid the courts. The consequence of this would be that we would have two systems, and the injury to the industries of the United States cannot be computed in dollars and cents. The confusion that would arise would be very great.

Thousands of us have spent a lifetime studying and arranging the necessary clearances and measurements which are correlated in the machinery that has served the people of this country and helped to make its great wealth. Many of us have put a study into the use of these measurements such as few men outside of our industries have any conception of. This study on the part of so many hundreds of thousands of men in this country has made our country what it is, and to ask these men to throw away their work of a lifetime and attempt to translate that work of years into another system of measurements is like asking them to not only learn another language themselves, but also to teach their workmen another language, they being meanwhile held responsible for the consequences. That is a demand entirely unreasonable and equally purposeless.

We are threatened with a law to compel us to use an inferior system. To those who are advocating this law, but who are not responsible for earning the dollars and cents that support our people through our industries, we say: "It is none of your business, but is the business of us who measure the products through which the taxes are paid, and we will fight you to the bitter end."

Industrial Conditions in Italy

By ERCOLE VAGHI, Milan, Italy

IN the May, 1919, number of MACHINERY, in an article entitled "Prospects for American Machine Tools in Italy," the writer reviewed the conditions of the Italian machine tool market as they then existed. The events since that time have confirmed the opinions expressed in that article. The writer has recently made a visit to many of the most important manufacturing plants in Italy with a view to selling American machine tools in the Italian market. The present article contains a summary of his impressions.

German Machine Tool Competition

The competition of German machine tools is still weak in Italy on account of the unstable conditions existing in Germany. German commercial travelers are again covering Italy in order to make business connections, especially for tools and accessories; but their quotations are uncertain as regards both price and time of delivery, and hence no one is inclined to make any deals that involve future conditions. I understand, however, that German manufacturing concerns are making enormous efforts to put their depressed industries on their feet again, and there is no doubt here that they will succeed, in time, in doing so.

The German competition, of course, is made easier by the low value of the German mark, but the German Government, on account of excessive sales abroad at low prices, has intervened, so that export prices must now be made somewhat in proportion to the values in the country where the goods are to be sold. Even with this additional increase in price, present quotations would be very favorable for sales in the Italian market, provided there were a greater certainty as to stability of prices and deliveries.

England, now as before the war, is taking very little interest in the Italian market, and but small efforts are made to gain a foothold in the machine tool trade. As regards small tools, some manufacturers are trying to sell in Italy, and offer much better prices than American manufacturers. No machine tools are offered from France, but France is entering the market with small tools on a small scale.

Italian Industrial Conditions

Italian manufacturers of automobiles, railway cars, locomotives, and electrical machinery, as well as the shipyards, are extremely busy and are anxious to buy new machinery in order to re-equip and expand their plants.

The factories are overcrowded with work for two reasons: First, the country demands products to replenish the depleted stocks exhausted during the war; second, the manufacturers are keeping selling prices much too low under present conditions. The workers in the shops, interpreting the great activity of the factories as an indication of prosperity, are, therefore, pushing their demands for higher wages, and the manufacturers find that the only method in which the situation can be properly met is by the introduction of modern labor-saving machinery. This condition in the Italian market should prove favorable to American machine tool builders if it were not for the fact that the value of the dollar, which was 6.34 lire at the armistice, is now, early in March when this is written, about 18.50 lire. This condition has caused a serious depression in commercial activities and the unfavorable conditions have been further augmented, by the strikes of the post, telegraph, and railway employes in the early part of the year. It might be mentioned that these strikes have been squarely met by the Government, which has known how to separate the just claims from those that were absurd.

The enormously high value of American money has caused a corresponding increase in purchase prices in Italy, so that, expressed in lire, the increase in the price of machine tools in Italy is from 230 to 300 per cent, while the actual increase in a year, in dollars, is only from 17 to 37 per cent.

The Predicament of the Italian Buyer

It is evident that the Italian machine tool buyer faces considerable difficulty under these conditions. If the dealer orders and keeps machines in stock, there is a possibility that, as the exchange conditions become less adverse, the Italian price will drop. Buyers naturally hesitate to conclude a deal at the present time, because they do not want to find themselves in a position of having made heavier investments for the same equipment than their competitors, who are waiting for better times. On the other hand, the buyer must be careful in ordering because of the possibility of a further rise of the dollar. If he orders at the present time, payable against presentation of bill-of-lading, the machines may be dearer than at the moment when they are ordered.

In order to face this serious state of affairs, which seriously threatens the commercial connections between America and Italy, the best suggestion would be for the American manufacturers to grant some terms of payment to the Italian buyer such as would permit him to choose, within a fixed period—say one year—the most favorable moment for paying the invoice. If the American manufacturer would accept the payment at any time within one year, guaranteed by a deposit in an Italian bank of the full amount in lire at the exchange rate at the time of sale, with payment of interest for the period of the deferred payment, it would be possible to find customers for machine tools not otherwise obtainable. If the value of the dollar in Italy drops, as the buyer evidently hopes, he will, under this arrangement, pay a smaller amount in lire than otherwise, while the American manufacturer receives the same amount in dollars. The Italian buyer gains two advantages; he pays a lower price, and he can use the machine at once. On the other hand, if the exchange should rise still further, the buyer nevertheless has the advantage of using the machine that he has bought, which his waiting competitors cannot do, and if he prefers to wait with the payment until a year later, he will have earned a part of the purchase price.

Stability of Italian Conditions

On the part of American manufacturers, the granting of credit to Italian buyers might be dangerous if there were any possibility of a financial crisis, or a threat of Bolshevik disturbances in Italy, but both of these possibilities must be excluded. The demand for manufactured products of every kind is extremely strong; all factories have orders that will keep them busy for a long time to come, and the exportation of products of Italy are increasing, which in time will bring the exchange back to a more normal rate. As regards dangers of disturbances of a revolutionary character, all such trouble in the past has been confined to small centers. Among the people of every country, and therefore also in Italy, there exists an element which uses every occasion to promote disorder, but it should be said for the great majority of Italian workers that they are absolutely against the ideas of the new Russian gospel, because through the war the Italian workman has obtained a higher standard of living, so that he is not so easily disposed to try the adventure of unknown communism.

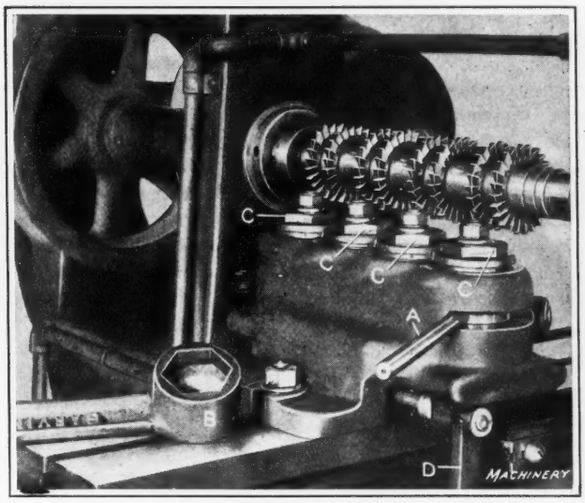


Fig. 14. Milling Machine equipped for straddle-milling the Flats on Hex-heads of Spark Plugs

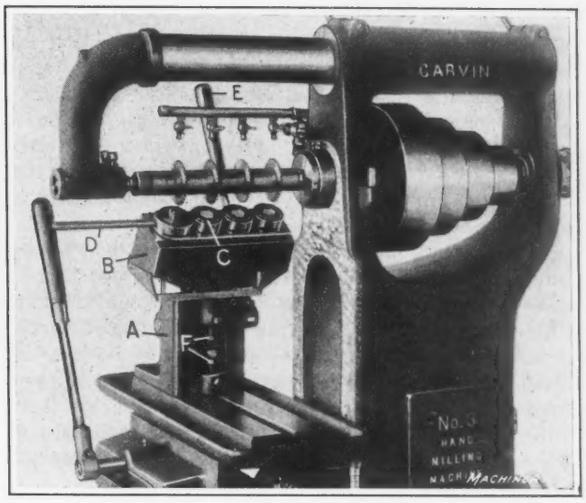


Fig. 15. Milling Machine equipped with Vertical Feed Attachment and Indexing Fixture for castellating Nuts

Indexing Milling Fixtures

Last of a Series of Three Articles on the Use of Indexing Fixtures for Obtaining Increased Production in Milling Practice

IN the first installment of this article, reference was made to the fact that machines equipped with fixtures of this type may be employed for the performance of two general classes of milling operations: First, in order to increase the rate of production through reducing the non-productive time of the machine and its operator, and second, to locate the work in two or more successive positions for milling the pieces to a square, hexagonal, or some other similar form. An example of the latter type of indexing milling fixture is shown in Fig. 14, which illustrates a No. 21 back-geared plain milling machine built by the Garvin Machine Co., New York City, engaged in milling the hexagonal heads of spark plugs for the ignition system on motor car engines. Machines equipped in this way are used at the plant of the Champion Ignition Co., North Flint, Mich.

Four pieces of work are set up in a multiple fixture, and by manipulating a single lever *A*, all four pieces may be indexed to the three successive positions in which they are held for straddle-milling opposite sides of the hex-heads. To obtain these settings of the work, lever *A* is moved into three successive positions, and in so doing it imparts motion to gearing that connects all four of the collet chucks of the fixture. In this way, a great deal of time is saved that would otherwise be lost if it were necessary to index each chuck individually. The chucks are of the double-tapered contraction collet type, and they are tightened r loosened by turning a wrench *B* that fits over a hexagonal collar *C* at the top of each collet.

In operating these Garvin No. 21 millers, the table is fed forward by power until a stop is engaged, which automatically trips the table feed-worm out of mesh with the worm-wheel. The operator then returns the table to the starting point with a handwheel; and after the collets have been loosened by using wrench *B*, lever *D* is lifted to manipulate the ejecting mechanism, which discharges the finished pieces from the fixture. When fresh blanks have been set up and secured in the collets, the machine operator lifts a lever, which re-engages the feed-worm ready to start the next operation. Of course, it will be apparent that it is necessary to make three cuts for each setting of the work. The table carries the work between the cutters, and continues its forward movement until the feed is automatically tripped. Then the operator returns the table to the starting point, and changes the position of lever *A* to index the work ready for the second cut, after which the power feed is re-engaged. This cycle of movements is repeated a third time to finish the work, after which the milled parts are removed and fresh pieces set up as previously described.

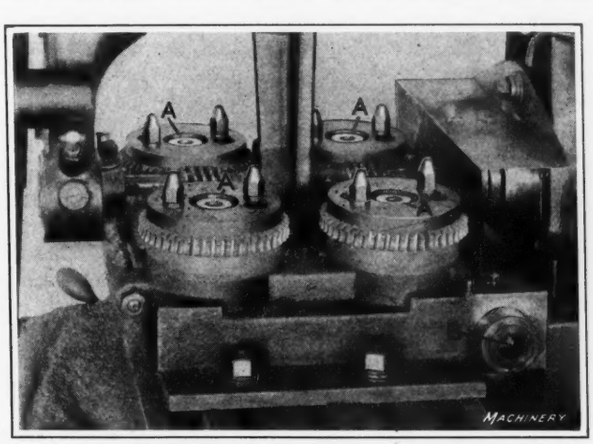


Fig. 16. Milling Machine equipped with Hobbing Fixtures for generating Teeth of Worm-wheels

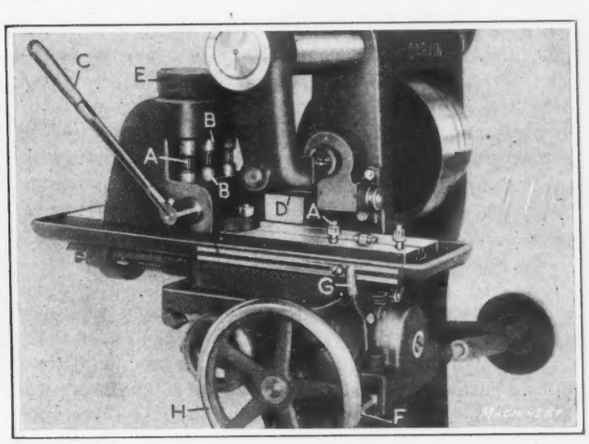


Fig. 17. Milling Machine equipped for generating the Teeth of Small Worm-wheels shown at A

Vertical Feed Milling Attachment

Where the length of a milling cut is quite short, it is often more advantageous to feed the work vertically to the cutter, instead of employing a horizontal feed movement of the table. For handling such classes of work, the Garvin Machine Co. has developed what is known as a "vertical feed milling attachment," and Fig. 15 shows one of these attachments applied to a No. 3 Garvin hand milling machine. The attachment is shown at *A*, and it is furnished with an indexing fixture *B* that provides for holding four hex-nuts to perform a castellating operation on them. It will be seen that four slitting saws are mounted on the milling machine arbor and the work-holding fixture is furnished with four sockets *C*, into which the nuts are dropped. As the work is fed vertically up against the saws, no means for clamping the nuts was considered necessary. It will be evident from the illustration that there is a nut in the left-hand socket while the other three are ready to receive fresh blanks.

In castellating these nuts, three cuts are taken at right angles to the flats. A hand-lever *D* provides for indexing all four pieces into the three successive positions in which they must be held for taking the castellating cuts. The movement of this lever is limited in both directions, and when it is in one extreme position, the first cut is taken; then the lever is moved to an intermediate position to index the work for the second cut; and finally, the lever is swung over to the opposite extreme of its movement, to index the work for taking the final cut. It will be seen that lever *D* is secured to the first work-holding socket; and all of the sockets are so mounted in the fixture that they may be turned by gearing which connects the four sockets. Hand-lever *E* governs the vertical feed movement of the attachment, this lever being pushed down in order to raise the work to the cutters. After the final cut has been taken, the fixture is allowed to drop until stops *F* come into engagement, and operate an ejecting mechanism which lifts the four castellated nuts out of their sockets. It will be seen that provision is made for adjusting the position of stops *F* in order to adapt them for the requirements of various jobs.

Fig. 18. Indexing Milling Machine equipped with Automatic Fixture for simultaneously roughing out the Teeth of Four Bevel Gear Blanks

Hobbing Worm-wheels on a Milling Machine

During recent years, the trend of machine tool design has been toward the development of special tools for the performance of repetition operations on large quantities of duplicate parts. Most experienced industrial engineers would unquestionably recommend the installation of these special machines, where the volume of work is great enough to enable a satisfactory return to be earned upon the investment in plant equipment. But there are many shops handling a general line of work, which do not have to machine a sufficient quantity of any one part to justify the installation of special machine tools. Consequently, it is necessary for them to adapt standard types of machinery for handling these jobs, and where sufficient ingenuity is displayed by the tool designers, extremely satisfactory results can often be obtained. The No. 13½ Garvin plain milling machine, shown in Fig. 16, equipped for generating the teeth of worm-wheels, is a case in point. The Garvin Machine Co. entered into an agreement to produce a number of these wheels, although the quantity to be cut was not great enough to justify investment in a special hobbing machine. After giving the matter some thought, it was found that a satisfactory equipment for handling the work could be produced by designing a special fixture for use on the milling machine. At the angle from which this fixture is shown in Fig. 16, the illustration is a little misleading, as it might be inferred that the teeth of four worm-wheels are cut simultaneously. As a matter of fact, this is not the case, because a generating operation is being performed on two wheels while the two other finished wheels are being removed from the fixtures and fresh blanks set up ready to have the teeth cut.

It will be evident that a clamping plate *A* is held down on each gear blank by means of two nuts. Considerable time would be required to screw these nuts all of the way off the clamping bolts, and to avoid reducing the output of the machine in this way, holes have been drilled in plates *A*, with slots running out from the holes. After a gear blank has been put in position, the plate is dropped over the nuts on the two clamping bolts, the holes in the plate being of sufficient size to clear these nuts. Then the plate is twisted so that the bolts slide into the slots, which are just wide enough to receive the bolts and allow the nuts to find a bearing surface on the top of the plate. With such an arrangement, it is only necessary to loosen the nuts about one-half turn in order to unload the fixture. For performing a hobbing operation, it is a matter of general knowledge that the work must be rotated while in contact with the hob. This result is accomplished on the fixture shown in Fig. 16 by making connection between the milling machine spindle and the arbors on which the worm-wheel blanks are mounted. A spiral gear is mounted on the spindle nose and engages with a second gear mounted at the middle of a shaft, one end of which can just be seen at *B*. This shaft is held by a bracket secured to the bed of the milling machine, and the fixture is free to slide lengthwise on the shaft, which rotates but does not have any longitudinal movement.

An explanation has already been given of the way in which two wheels are being hobbed while the other two are

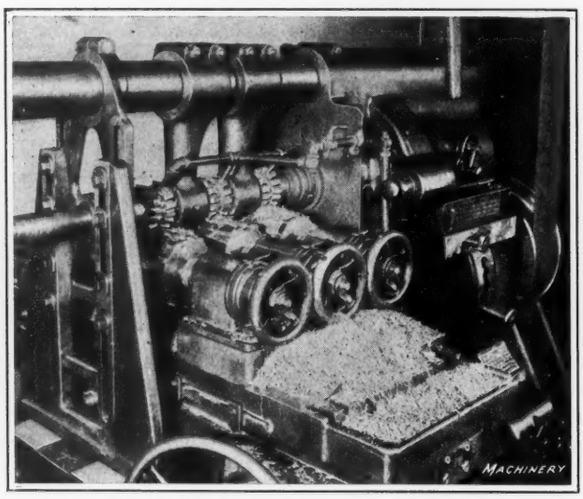


Fig. 19. Plain Milling Machine equipped with Three Sets of Special Single Dial Index-centers for fluting Forgings

in the idle position, so that the finished wheels may be removed and fresh blanks set up in the fixture. It is necessary to stop rotation of the finished work, and provision for so doing is accomplished by means of two clutches on shaft *B* which transmit power to the cross-shafts that drive the two pairs of work-holding arbors. When the table is moved over to bring two new blanks into contact with the hobs, one clutch moves out of engagement with the cross-shaft through which power is transmitted to the arbors on which the two finished worm-wheels are mounted. At the same time, the other clutch comes into engagement with the cross-shaft that transmits power to the arbors on which the two fresh gear blanks are carried. In this way, it will be apparent that disengagement and engagement of the drive is automatically accomplished when the table is moved over by hand to bring two fresh blanks into the operating position. The worm-wheels to be hobbed have 48 teeth of 10 diametral pitch, so that they are 4.8 inches in diameter. On this job, the teeth of two worm-wheels were completely cut every seven minutes.

Hobbing Small Worm-wheels on a Milling Machine

Another milling machine equipped for hobbing the teeth of worm-wheels is illustrated in Fig. 17. This is a No. 21 plain miller built by the Garvin Machine Co., and it is used at the plant of the Frank Mossberg Co., Attleboro, Mass., for generating the teeth of small worm-wheels shown at *A*. The equipment of the machine for this job is rather different from the one shown in the preceding illustration. Only one work-holding fixture is mounted on the table, and in order to reduce idle time of the machine as far as possible, especial attention was paid to the provision of a quick-clamping mechanism. It will be seen that a small trunnion projects out at each side of the worm-wheels *A*, and these trunnions are used for holding the work in bushings *B*, which are bored out to receive the trunnions. The three upper bushings occupy fixed positions in the fixture, but the lower bushings have rack teeth cut in them, which mesh with pinions carried by a cross-shaft. Lever *C* is mounted at the end of this cross-shaft, and by pushing the lever down, the three lower bushings are withdrawn so that the hobbed worm-wheels may be removed from the fixture and fresh blanks substituted in their places. Provision is made for rotating the work while the hobbing operation is in progress, by means of a shaft *D* that takes power from the milling machine spindle through a worm-wheel and worm. This shaft transmits power to gears contained in case *E*, which are so arranged that all three spindles are driven simultaneously from the single source of power. After the fixture has been loaded, lever *F* is raised to bring the feed-worm into engagement with the worm-wheel, so that the work is fed to the cutters until the automatic stop *G* is engaged, thus tripping the feed at the time that the hobbing operation has been completed. The table is then returned to the starting point by handwheel *H*.

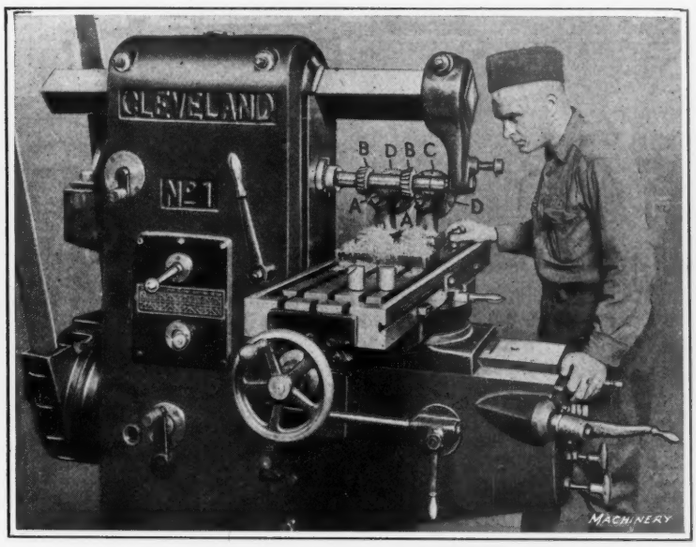


Fig. 20. Universal Milling Machine equipped with Indexing Fixtures for cutting the Teeth in Milling Cutters

Roughing out the Teeth of Bevel Gear Blanks

Experience has shown that in operating various types of bevel gear generators, more satisfactory rates of production can be obtained by performing the operation in two steps—first, roughing out the teeth, and second, performing the final operation of generating the teeth to the required form. Several types of machines have been developed for use in roughing out the teeth of bevel gear blanks which are to be finished on a special generating machine. Fig. 18 shows an automatic machine developed for this purpose by the Garvin Machine Co. This machine is used at the plant of the Reo Motor Car Co., in Lansing, Mich. It consists of a No. 9 indexing miller equipped with a fixture on which provision is made for mounting four gear blanks. It will be seen that two rotary gear-cutters are mounted on the arbor of the milling machine, and the gear blanks are mounted in two pairs, each pair of blanks being held on an inclined plane, so that the portions of the faces in which gear teeth are to be cut are held in a horizontal position. With such an arrangement, each pair of gear blanks can be fed under one of the cutters to provide for milling a tooth space in each of the blanks. After this has been done, the direction of table movement is automatically reversed and the table is returned to the starting point at high speed. Next, each of the four gear blanks is automatically indexed through one tooth space, and after this has been done, the forward feed movement of the table is again automatically engaged to move the work forward for cutting the next tooth space in each of the blanks. With such an arrangement, it is only necessary for the operator to set the blanks up on the machine, after which the work requires no further attention until all of the teeth have been cut. On this job, the work is fed to the cutters at a rate of 9 inches per minute, and there are 40 teeth to be cut in gears having a face width of 1½ inches. The machine completes the operation in 13 minutes, 20 seconds.

Milling Grooves in Steel Forgings

Fig. 19 shows a Brown & Sharpe No. 5B heavy-duty plain milling machine equipped with three sets of index-centers to provide for milling two grooves in six steel forgings at each traverse of the table. The grooves are each 1.17 inches wide by 5/16 inch deep, and two forgings are mounted on the arbor between each pair of index-centers. It will be apparent from the illustration that the cutters are formed in such a way that they mill two grooves and also finish the top of the raised portion of the work between two adjacent grooves. After the cut has been completed, the table is returned to the starting point and the work is then indexed ready for taking the next cut. This is an exceptionally heavy job, and to enable it to be handled, it is necessary to use an arbor possessing ample strength; otherwise, there would be a tendency for the arbor to spring. To avoid trouble from this cause, it will be seen that the cutter-arbor, which is of considerable length, is rigidly supported from the over-arm of the machine by means of two intermediate yokes placed between the cutters. The cutters and work are lubricated with lard oil to prevent them from becoming overheated.

Fluting Hollow-milling Cutters

There are many examples of tool-room work, such as the fluting of various types of cutting tools, where it is neces-

sary to produce a number of pieces of a standard form. For such jobs, the use of an indexing milling fixture will often enable rates of production to be substantially increased. Fig. 20 shows a No. 1 universal milling machine built by the Cleveland Milling Machine Co., Cleveland, Ohio, which is equipped with an indexing fixture to provide for simultaneously fluting two hollow-milling cutters. It will be seen that the cutter blanks *A* are held in collet chucks; and two angular milling cutters *B* are mounted on the arbor of the machine. To save as much time as possible in indexing the work for taking successive cuts, it will be seen that an index-plate *C* is mounted at the rear end of one of the work-spindles, this plate being notched to receive an index-pin which locates the cutter blank held by the fixture in position for milling. A pair of spur gears *D* connects the spindles of the two fixtures together, so that when the spindle that carries the index-plate is turned through the required angle to bring the work into position for taking the next cut, the piece of work carried by the other spindle is simultaneously located. The angular milling cutters *B* are made of high-speed steel, and on this job the cutters were driven at 81 revolutions per minute, which corresponds to a cutting speed of 63.6 feet per minute; and the work is fed to the cutters at 2.15 inches per minute.

* * *

TRAINING OF INDUSTRIAL ENGINEERS

In an article on engineering education, appearing in *Industrial Management*, P. F. Walker, dean of the School of Engineering of the University of Kansas, calls attention to the need for special training of men who are primarily engineers, but whose activities will lie more directly in the production field of organized industries; in short, for industrial or production engineers. Attention to this phase of technical education has been drawn by representatives of the Federal Bureau of Education. Emphasis has been given in this way to the need for men of combined technical and business training, with particular reference to the needs of organizations engaged in the foreign trade. Three conferences have been held, attended by engineering and commercial school representatives, the result of which has been recommendations addressed to the universities and technical schools for greater attention to the business training of engineer students. The plan is to substitute for an amount of technical work, amounting to nearly one year's time out of four, class work in economics and accounting of the same type as that to which major attention is given in the schools of commerce. The result of such changes in existing courses of study should be to turn out men who have the fundamental groundwork of technical engineers and who are also equipped to qualify readily for sales duties and as representatives of exporting firms in foreign territory. Such modified courses of study correspond in many ways with courses in industrial engineering now given in four or five technical schools in this country. To develop such training courses to the best advantage and with a minimum of lost motion, it is essential that firms engaged in foreign trade and needing such men should be in close co-operation with the schools, and should make their requirements known.

SLIDE-RULE FOR CALIBRATING TANK GAGE STICKS

It is common practice to have tanks for holding gasoline and other kinds of oils made of a cylindrical form and mounted with the axis in a horizontal position. Where a tank is set up in this way, special means must be provided to ascertain the volume of oil which remains in the tank at any time, because a determination of the contents from a knowledge of the dimensions of the tank and the depth of the fluid, is a difficult mathematical problem. S. F. Bowser & Co., Inc., of Fort Wayne, Ind., make a specialty of building equipments for the storage and handling of various fuel and lubricating oils, and to enable their customers to easily ascertain the volume of oil contained in a cylindrical tank lying in a horizontal position, this concern follows the usual practice of furnishing a gage stick with each tank. This gage must be calibrated for the tank with which it is to be used, and in accordance with the usual method, each stick is graduated so that it may be dropped into the tank from the top and, by noting the height to which the stick is submerged in the oil, a direct reading can be obtained of the volume of oil in the tank.

To facilitate the work of the engineering department in calibrating these gage sticks, a special slide-rule was designed and made for use in the office of the factory engineer. This instrument is shown set up in the engineer's office in Fig. 1, and Fig. 2 represents a diagram which gives a clear idea of the way in which this slide-rule is used. Referring to Fig. 2, it will be seen that there are two fixed scales at the front and back of the rule, two movable slides designated as the "front" slide and "back" slide, two movable glasses each carrying an index line, designated as "front" and "back" glass, and fixed "side" glasses carrying index lines that coincide with the end lines of the fixed front and back scales. The fixed scale at the front and back, together with scales *D*, *E*, and *F* on the slides are exact duplicates of scales *C* and *D* of the ordinary slide-rule. Scales *A*, *B*, and *C* on the front slide are laid out to give a direct reading of the percentage of the whole diameter of the tank that represents the depth of the liquid in the tank, corresponding to the percentage that the number of gallons on the *D* scale is to the whole capacity of the tank in gallons. This can be done because there is a fixed relation between these percentages, that depends in no way on the diameter or the capacity of any particular cylindrical tank.

In other words, when a number on the *D* scale, corresponding to the number of gallons of oil left in the tank, is placed opposite the number on the fixed front scale which represents the total capacity of the tank in gallons, either scale *A*, *B*, or *C* on the front slide will indicate the required percentage, a direct reading of this result being obtained under the graduation on the side glass. Scale *A* is read when the number of gallons left in the tank is from 0.1 to 1 per cent of the full capacity of the tank; scale *B*, when the result is from 1 to 10 per cent; and scale *C* when the result is 10 per cent or greater. It will be evident that the operation of determining any percentage of the full tank capacity is similar to the familiar process of making a division

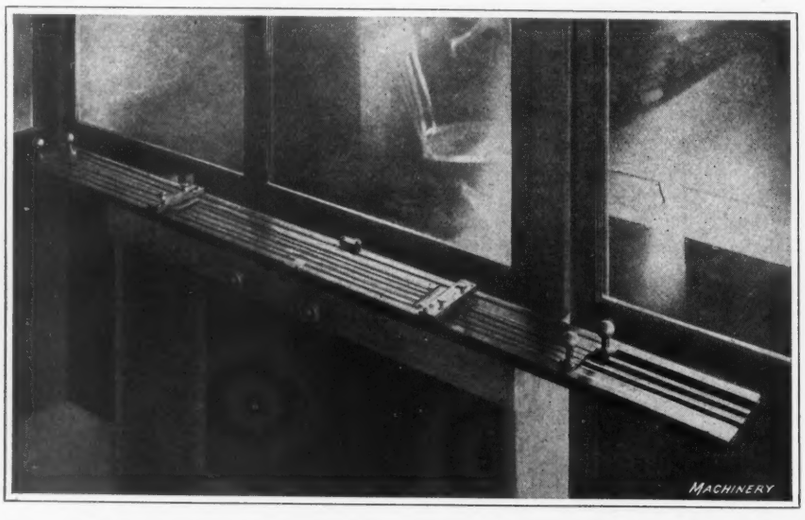


Fig. 1. Slide-rule used in Factory Engineer's Office for Use in calibrating Tank Gage Sticks

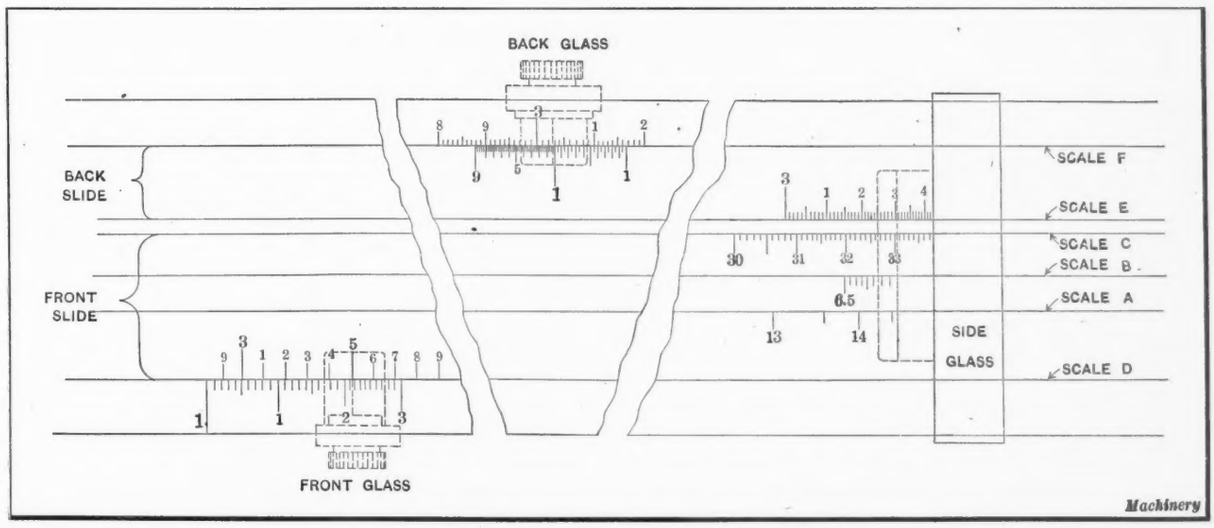


Fig. 2. Diagram showing a Partial Lay-out of the Special Slide-rule for calibrating Tank Gage Sticks

on an ordinary slide-rule, except that scales *A*, *B*, and *C* have been laid out in such a way, and in such a relationship to scale *D*, that the result of the division is expressed directly as a percentage, and is read under the index on the side glass. Scales *E* and *F* and the fixed back scales are, as stated before, logarithmic scales, and for that reason the reading of scale *E* under the side glass is always the percentage that any number on scale *F* is of its corresponding number on the fixed back scale.

In using this slide-rule for calibrating a gage stick, the method of procedure is as follows: First, set the back glass over the number on the fixed scale at the back of the slide-rule, which indicates the diameter of the tank in inches (in this case, 30¼ inches). Second, set the front glass over the total capacity of the tank in gallons (in this case, 121.3 gallons). Third, move the front slide along so that the number of gallons of oil in the tank also coincides with the index line on the front glass (in this case, 35 gallons). Fourth, under the graduation on the side glass read in per cent the ratio of the depth of oil in the tank to the total diameter of the tank (in this case, 33.01 per cent). This result is read on scale *C* because the number of gallons is over 10 per cent of the full tank capacity. Fifth, move the back slide to bring the same percentage reading on the *E* scale under the index line on the side glass as the reading which is located under this index on the *C* scale of the front slide. Sixth, the reading of the height of the required graduation mark from the bottom of the gage stick is then found on the *F* scale under the index on the back glass (in this case 9.99 inches).

In laying out a gage stick, the actual method of procedure is to mark on the stick a height from the bottom equal to the diameter of the tank, and then mark off intermediate points along this diameter distance. The slide-rule will then be employed to determine the number of gallons which correspond to the graduation marks on the gage stick, and each of these numbers of gallons will be marked beside the corresponding lines. Such a stick can be used to dip into a tank partially filled with oil to quickly ascertain the number of gallons which are represented by any specified depth. The scales on the slides were duplicated in lengths in order to be able to read them under either side glass without having to move the slide the whole length of the rule, as is necessary with the common slide-rules, when the results come outside of the fixed scale. The knobs on the slides (see Fig. 1) are used for rapid movement of the slides, while the handwheels (one for each side) shown in front are used to give a micrometer-like movement to the slides. The graduating of the slide-rule was done on a milling machine after the logarithms of the numbers representing the required values had been tabulated.

POINTERS ON SPRING WINDING

By GEORGE C. HANNEMAN

The man who only occasionally has to make a helical wire spring is usually somewhat baffled at first at the seemingly inconsistent action of springs. For instance, it is frequently noticed when a spring of perhaps twenty turns has been made and the turns carefully counted in winding, that after the spring has been made, actually only seventeen or eighteen turns are obtained. It should be remembered that a spring enlarges in diameter when the winding tension is removed, and that a small spring will not increase in diameter as much as a larger one of the same size wire. If the spring is found to be 1/16 inch over size after the first trial, the mandrel should not be turned down a full sixteenth, because if this is done it will be found that the spring wound on this mandrel is too small. The mandrel should be turned down a little less than 1/16 inch as determined by trial, in order to obtain a spring of the desired size.

It should be remembered that a spring made of music wire is subject to an internal strain, tending to enlarge it unless this strain is relieved when the spring is made. This fact may manifest itself after the spring has been allowed to set for several days, and will be apparent by the enlarged diameter, shortened length, and decreased number of turns. This fact may be emphasized by an experience of the writer. A number of springs were made of music wire with an eye bent up on both ends of each spring, the eyes being exactly in line. When an attempt was made to assemble these springs a few days later, it was found that the eyes had changed their relative positions and were more nearly at right angles to each other than in line.

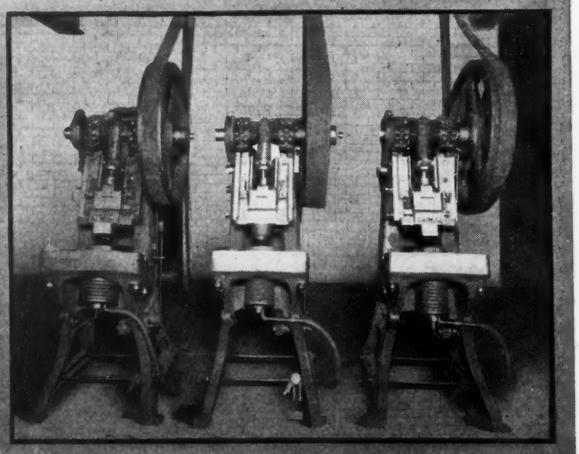
It is good practice in winding springs of tempered wire, which are not to be subsequently hardened, to relieve the internal strain by "backing up" the spring a little. This may be conveniently done, by simply inserting a rod of suitable size in the spring, and turning the ends in a direction tending to enlarge the spring diameter. To allow for subsequent enlargement and shortening, springs should be wound a little under size, and should have two or three extra turns. By observing these precautions, a spring may be obtained that will hold its size.

* * *

Alloys of the aluminum-magnesium-copper series are superior to other aluminum alloys in regard to tensile properties. These properties may also be improved considerably by proper heat-treatment. Alloys of the aluminum-magnesium-nickel series are also improved by heat-treatment, but not to the same degree as the first series mentioned. Alloys of the aluminum-magnesium-manganese series are not improved by heat-treatment.

Pneumatic Cushions in Metal-Drawing Operations

By JOHN NELSON



Description of Various Types of Pneumatic Die Cushions Used in Connection with Punch Presses, and Methods of Installing

ONE of the most vital factors to be considered in the process of drawing various shaped parts from sheet metal is the pressure that must be applied on the metal as the flat blank is drawn into the desired shape. This pressure should be just enough to keep the metal of the shaped part or shell smooth at all stages of the operation. If the metal is unduly strained at any time, its toughness is lessened, which often results in the breakage of the shell during either the first or succeeding drawing operations. An excessive pressure is a waste of power, produces an avoidable strain on the machine, and causes a great amount of wear on the die parts, especially on the drawing ring and the blank-holder. Wrinkles which may be formed on the shell in any of the drawing operations are, of course, a disadvantage, but they are often tolerated when it is not absolutely essential that the finished article be entirely smooth, with the result that die parts also become excessively worn on this account. Thus it is important that some means be employed to produce a uniform pressure while drawing.

Advantages of Pneumatic Die Cushions

The double-action or toggle type of press was designed to produce a uniform pressure on the blank during the operation, and has proved a success in most cases. In some instances, however, this type of press has proved inefficient, and pneumatic die cushions have been developed to remedy conditions. By means of these cushions a uniform pressure can be applied on the shell at all times regardless of the unevenness of the blank or the thickness of the metal during the operation. This is the greatest factor in favor of air cushions for this purpose, but there are others, some of which are as follows: (1) The initial cost of a single-action press equipped with pneumatic cushions, which will perform operations usually performed on double-action presses, is only about one-half that of a double-action press. (2) The equipment is less cumbersome and can be operated at higher speed. (3) A machine provided with this equipment can be used for more than one purpose, whereas an ordinary drawing press is suitable only for a drawing operation. (4)

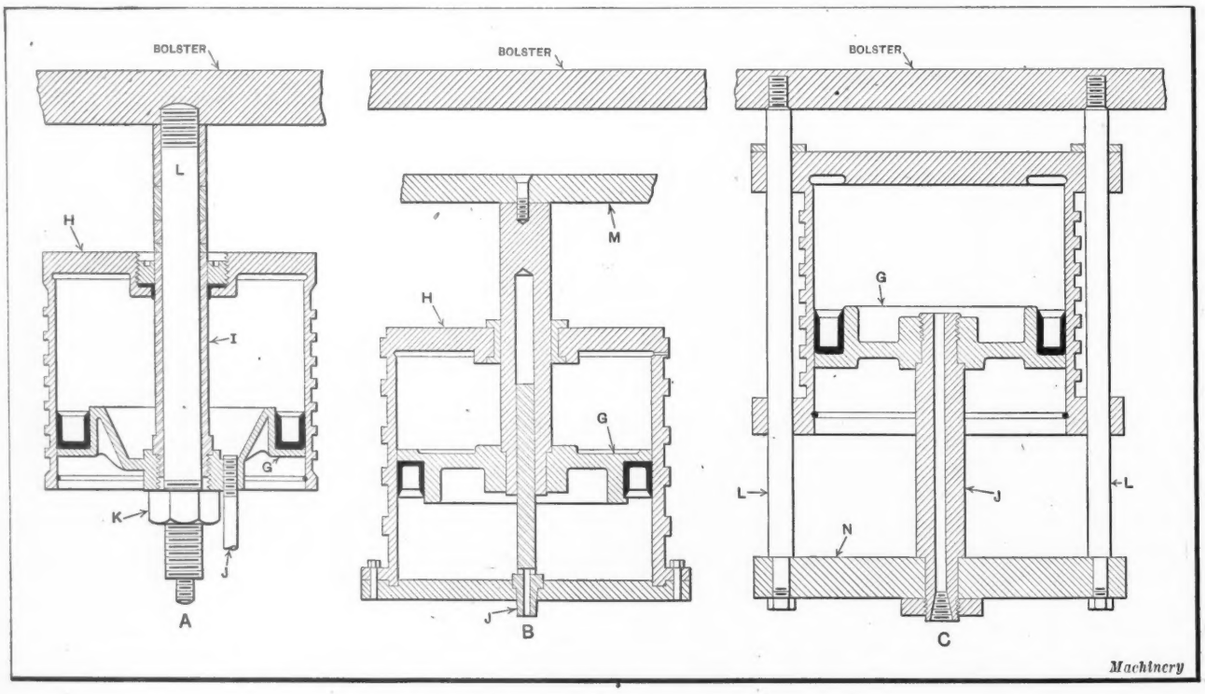


Fig. 1. Construction of Pneumatic Die Cushions

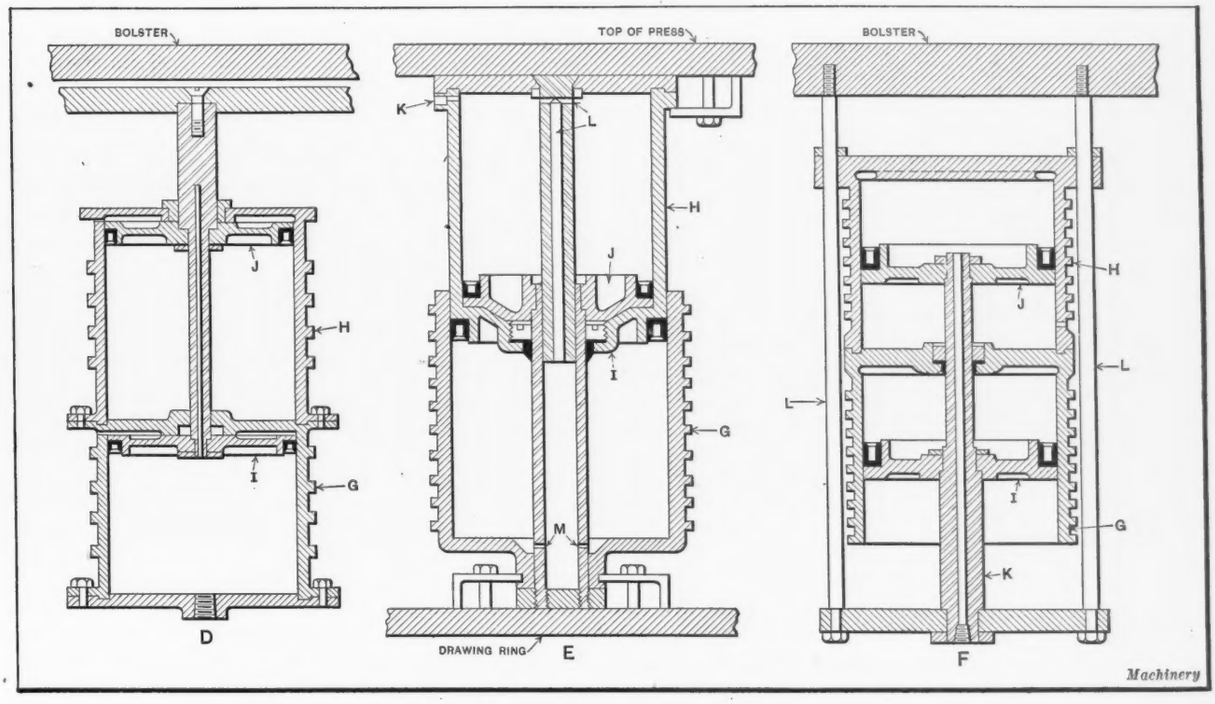


Fig. 2. Various Types of Double-unit Pneumatic Die Cushions

A smaller size machine can be used than when springs or rubber buffers are employed to supply pressure on the blank, because it is not necessary to overcome increasing pressure, and so power is saved and unnecessary strain on the machine is eliminated.

Various Types of Air Cushions Suitable for Punch Presses

It therefore seems apparent that air cushions are the key to the successful and economical solution of many metal-drawing problems. Various types of these cushions have been recently developed by the Marquette Tool & Mfg. Co., Chicago, Ill., to meet a large variety of requirements, the size ranging from cushions having a piston 6 inches in diameter, which are suitable for machines drawing shells to a depth of 2 inches, to cushions which have a piston 20 inches in diameter, which are intended for presses drawing shells to a depth of 8 inches. These cushions can be applied to machines singly or in batteries. Some of these types are illustrated in Figs. 1 and 2. In the type shown at *A*, Fig. 1, piston *G* remains stationary when compressed air is admitted into cylinder *H*, while the cylinder rises vertically on sleeve *I*. The pins that support the drawing ring of the die rest upon the top surface of the cylinder, and thus as the cylinder is forced upward, pressure is applied on the drawing ring. The air is admitted into the cylinder through pipe *J*. Nut *K* permits the various parts of the cushion to be removed from

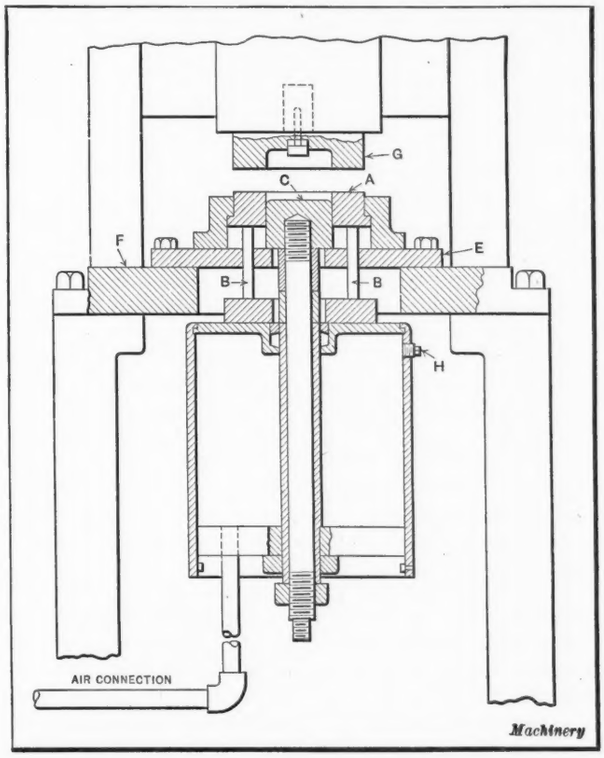


Fig. 3. Air Cushion attached to the Die of a Punch Press

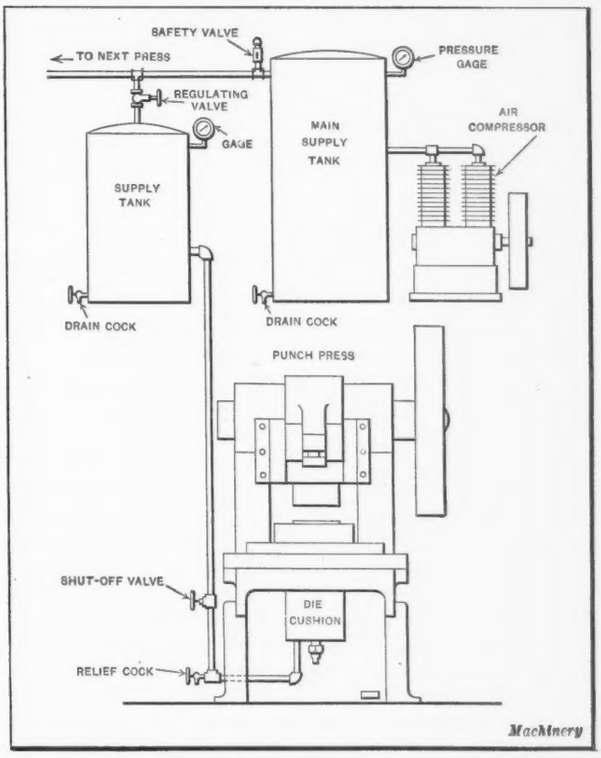


Fig. 4. Method of connecting Air Cushion Equipment

the machine without requiring stud *L* to be disassembled. This cushion design is used singly, as a rule, but it can also be applied in multiples on double- or multiple-crank presses.

In the design shown at *B*, cylinder *H* remains stationary and piston *G* is forced vertically upward when compressed air is admitted into the cylinder through connection *J*. The drawing-ring pins rest upon the pressure-pad *M*. This type of cushion is installed principally in batteries on double- or multiple-crank presses. Another design of cushion in which the piston remains stationary while the cylinder is forced upward when air is admitted into it is shown at *C* in the same illustration. Piston *G* is supported upon fitting *J* through which air is forced into the cylinder. This fitting is mounted in plate *N*, which is attached to the bolster of the press by four rods *L* which also act as guides for the cylinder. The die pins rest upon the top of the cylinder.

The types of pneumatic cushions illustrated in Fig. 2 really consist of two sets of cylinders and pistons in one unit. In the design shown at *D*, cylinders *G* and *H* remain stationary when air enters the cylinders, while pistons *I* and *J* are forced upward. This type of cushion is used chiefly on double- or multiple-crank presses. In the design shown at *E*, air is admitted into cylinder *H* through inlet *K*, and into cylinder *G* through holes *L* and *M*. The illustration shows this cushion applied to the top of a hydraulic press. When there is no air in these cylinders, piston *J* is raised to the top of cylinder *H*, and cylinder *G* telescopes over cylinder *H*, the latter remaining stationary when air is admitted into the cylinders, and piston *I* of cylinder *G* serving as the head of cylinder *H*. This type of air cushion is used principally in batteries, the various units being connected by flexible tubing. They may be placed in any position on the drawing ring so that pressure can be distributed as desired.

In the air cushion shown at *F*, cylinders *G* and *H* move vertically on four guiding rods *L*, which also act as a support for other parts of the cushion. Pistons *I* and *J* are stationary on connection *K*, through which air is brought into the two cylinders. The die pins which support the drawing ring rest upon the top surface of cylinder *H*. Batteries of cushions of the types shown at *B*, Fig. 1, or *D*, Fig. 2, are generally used on large presses such as are employed in drawing automobile fenders, body parts, and radiator fronts; steel barrels, etc. The cushions of the type illustrated at *A* and *C*, Fig. 1, and *F*, Fig. 2, are used on presses employed in drawing automobile lamp bodies, oil-cans, clock cases, cuspidors, enamelware, grease cups, etc. An air cushion that operates on the same principle as the one shown at *A* in Fig. 1 is shown in Fig. 3 connected to the forming die of a machine. In this illustration, *A* represents the drawing ring; *B*, the drawing-ring pins; *C*, the forming die; *E*, the die-shoe; *F*, the bolster plate; and *G*, the punch. Oil can be introduced into the cylinder by removing plug *H*.

Installation of Cushions Singly or in Batteries

Fig. 4 illustrates diagrammatically the method of connecting pneumatic die cushions to the supply tank and air compressor. This method of installation should be used when a number of machines are connected to the same main tank of compressed air, because it is absolutely essential that each press be provided with an individual air tank and air regulator so that a certain pressure may be maintained on any of the machines independently of the rest. When only one machine is supplied from the main tank the cushion can be connected directly to it. A record should be kept of the pressure used on each job so that when a similar operation is performed, experiments will be unnecessary in order to ascertain the correct pressure to be employed for the operation. The total pressure on the drawing ring can be determined by simply multiplying the pressure in pounds per square inch by the area of the piston in square inches.

In order to exert an even pressure on the drawing ring during an entire operation, it is necessary that the individual tank used in conjunction with the cushion be of ample capacity. When the tank is too small, the air pressure will be greatly increased as the air in the cushion is forced back into the tank on the downward stroke of the press ram, and, of course, the pressure on the drawing ring will be subsequently greatly increased. If the tank is large enough, how-

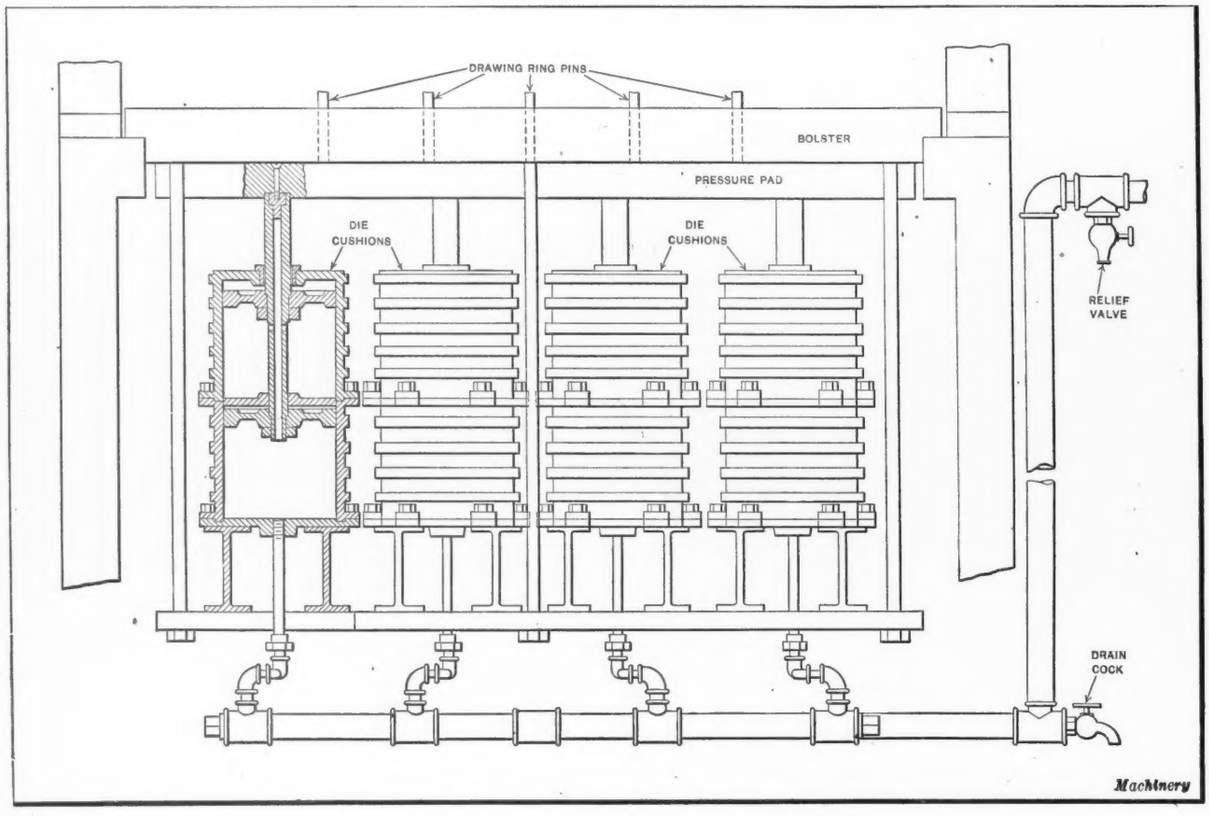


Fig. 5. Large Punch Press equipped with Battery of Double-unit Cushions

ever, no trouble arises from this source. The air cushion should also be of sufficient size so that a high air pressure in pounds per square inch is not necessary in order to obtain sufficient pressure on the drawing ring. One-stage air compressors are generally used in connection with these cushions, but their operation is uneconomical when the air pressure is more than 100 pounds per square inch. Besides this, excessive pressures are detrimental to the cushions. More pressure is required on the drawing ring when a part drawn from a thin-gage metal is being produced than when a thick-gage metal is being used, and so it is evident that a larger cushion is required for drawing light metal than for drawing heavy metal. Fig. 5 shows a large machine equipped with a battery of cushions of the type illustrated at *D*, Fig. 2.

The production of steel helmets for the United States Army was a metal problem which occurred during the recent war. These helmets were drawn from a high manganese steel of about 0.036 inch in thickness. The specifications required that the minimum thickness of the helmet should not be less than 0.030 inch at any point and that the height from top of the crown to the rim should be 4⅛ inches. It was generally thought that two operations on double-action presses were required to produce the part, and this method was used with varied success.

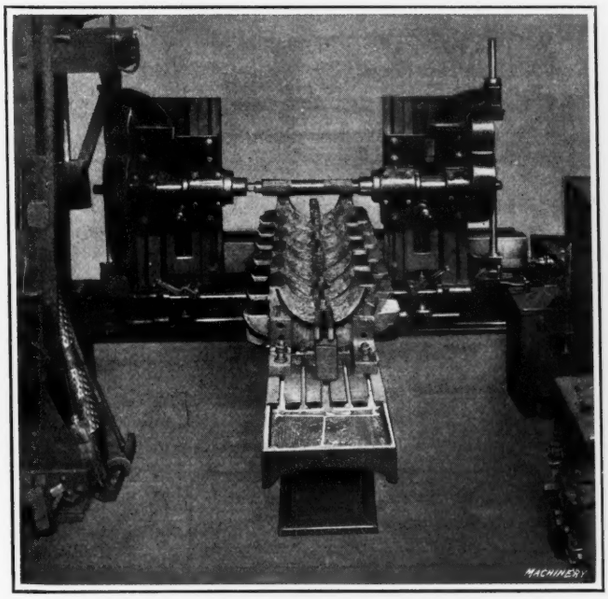


Fig. 1. Milling Top of Marine Engine Bearing Castings

The principal trouble with this method was that when the blank-holder was set close enough to the drawing ring so that wrinkles would not be produced on the shell, the blank would be held so tight that the metal which constituted the crown of the helmet would be stretched to a thickness less than the allowed limit. Hence wrinkles were tolerated so that the minimum thickness would not be less than specified.

The above facts were called to the attention of the firm previously mentioned in this article by a manufacturer who desired to produce helmets on a single-action press. The press was subsequently equipped with pneumatic die cushions, the female part of the die being held in the press ram. A pressure of about 21 tons was applied on the drawing ring by the cushions. The result was an average production of nine helmets per minute, the surfaces of which were smooth and the minimum thickness of each shell not less than 0.032 inch. The reason that the helmets were drawn in this manner without being excessively stretched was that the pressure on the drawing ring was the same during the entire operation regardless of the thickness of the metal. When these helmets were subjected to the shooting test, they were not penetrated by bullets, because the metal had not lost any of its toughness as a result of the drawing operation.

MILLING ENGINE BEARING CAPS

At the Allis Chalmers Mfg. Co.'s plant in Milwaukee, Wis., a planer type milling machine, built by the Pratt & Whitney Co., of Hartford, Conn., is used for performing four consecutive milling operations on large cast-steel bearing caps for marine engines. Rerference to the accompanying illustrations will clearly show the way in which the castings are set up on the machine for performing two of these operations, and also the nature of the work to be done, which consists of face-milling the sides and tops of the castings. It will be seen that seven castings are set up in a row, and that the string fixture, by which they are carried, is furnished with means of locating the work for milling, and straps for holding each casting down.

For the first operation performed on the top of the castings, the plane milling cutters are 5 inches in diameter and they are driven at a speed of 30 revolutions per minute, which represents a cutting speed of 39.5 feet per minute with a feed of 2¾ inches per minute. For milling the sides of the work, the cutters are 9 inches in diameter and they are driven at 17 revolutions per minute, which represents a cutting speed of 40 feet per minute with a feed of 2½ inches per minute. These castings are made of a tough grade of steel, and it is necessary to reset the machine for the next

Fig. 2. Milling Sides of Marine Engine Bearing Castings

operation after the preceding part of the work has been completed. The rate of production obtained is three complete castings per day. Attention is called to the fact that this production is for a total of four operations that are required on the work, there being two additional milling operations to perform on the opposite side to those shown.

* * *

Considerable progress has been made in designing safety devices to protect the eyes of workmen who operate emery wheels as well as other machine tools. Goggles and glass shields have been used for this purpose for some time. Recently transparent sheeting, such as used for automobile curtain windows, and a material known as safety glass have been tried with success. The safety glass is made either by laying a coarse mesh of fine wire in the glass, or by employing hydraulic pressure to weld a piece of transparent sheeting between two sheets of glass. However, for goggles used when operating emery wheels, the transparent sheeting alone has proved effective, and is much cheaper than any form of glass. Either the safety glass or transparent sheeting can also be fitted in a frame and held over the wheel in such a position as to deflect emery dust and metal particles away from the operator's eyes.

Stresses in Bolted and Riveted Joints

By VICTOR M. SUMMA, Engineering Examiner, American Brake Co., St. Louis, Mo.

IN Fig. 1 is represented a bracket A fastened to a channel B by means of bolts or rivets. It is required to find the stresses in the fastenings produced by a load W acting at O as shown. It is apparent that the fastenings, which will be considered to be bolts will be subjected to the following stresses:

1. The shear due to the direct action of W and indicated by the symbol S_s.

2. The shear due to the moment Wa', resisted by the moments of the bolts about their center of gravity as a center of rotation and represented by the symbol S'_s.

3. The tension due to the moment Wa, resisted by the moments of the bolts about edge XX of the bracket as the axis of rotation, and represented by the letter S.

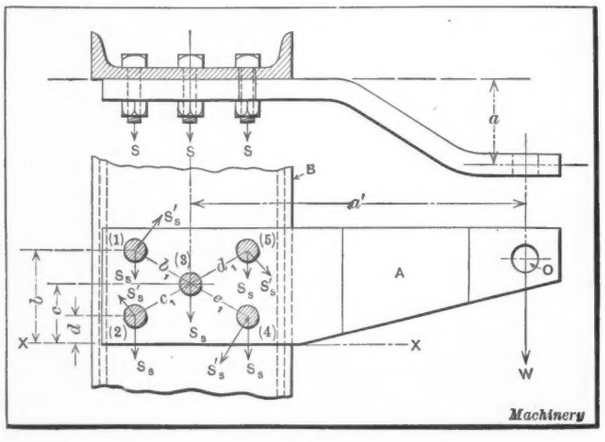


Fig. 1. Bracket attached to Channel, the Fastenings of which are stressed by the Load W

The value of S_s may be readily found, being simply the quotient of W divided by the number of bolts employed N, that is

$$S_s = \frac{W}{N} \qquad (1)$$

The values of S'_s and S are determined in the following manner: Let Q represent the stress produced in a bolt imagined to be located at unit distance from the center of rotation. Then the shearing stress S'_s in each bolt due to the moment Wa' at their actual distances is: Qb_1 for bolt (1); Qc_1 for bolt (2); 0 for bolt (3); Qe_1 for bolt (4); and Qd_1 for bolt (5). In a similar manner, the tension stress S in each bolt due to the moment Wa, with XX as the axis of rotation, may be expressed thus: Qb for bolts (1) and (5); Qc for bolt (3); and Qd for bolts (2) and (4). It follows that the sum of the moments of these forces must equal the moments that produced them. Therefore, by first taking the moments Qd_1, Qc_1 etc., about the center of gravity of the bolts (which obviously is the middle bolt) the equation may be written:

$$(Qb_1 \times b_1) + (Qc_1 \times c_1) + (Qd_1 \times d_1) + (Qe_1 \times e_1) = Wa'$$

$$Q = \frac{Wa'}{b_1^2 + c_1^2 + d_1^2 + e_1^2}$$

Therefore the actual stress S'_s for each bolt is the stress Q at unit distance from center of rotation, multiplied by the distance of each bolt from the middle bolt (3), thus:

$$\left.\begin{aligned}
S'_s \text{ for bolt (1)} &= Qb_1 = \frac{Wa'\,b_1}{b_1^2 + c_1^2 + d_1^2 + e_1^2} \\
S'_s \text{ for bolt (2)} &= Qc_1 = \frac{Wa'\,c_1}{b_1^2 + c_1^2 + d_1^2 + e_1^2} \\
S'_s \text{ for bolt (3)} &= Q \times 0 = 0 \\
S'_s \text{ for bolt (4)} &= Qe_1 = \frac{Wa'\,e_1}{b_1^2 + c_1^2 + d_1^2 + e_1^2} \\
S'_s \text{ for bolt (5)} &= Qd_1 = \frac{Wa'\,d_1}{b_1^2 + c_1^2 + d_1^2 + e_1^2}
\end{aligned}\right\} \qquad (2)$$

By following the same method for finding the tension stress S, taking the moments Qb, Qc, etc., about the axis XX, the equation of moments may be expressed thus:

$$(2Qb \times b) + (Qc \times c) + (2Qd \times d) = Wa$$

$$Q = \frac{Wa}{2b^2 + c^2 + 2d^2}$$

Therefore the actual stress S for each bolt is the stress Q at unit distance from the center of rotation, multiplied by its corresponding distance from the axis XX, thus:

$$\left.\begin{aligned}
S \text{ for bolts (1) and (5)} &= Qb = \frac{Wab}{2b^2 + c^2 + 2d^2} \\
S \text{ for bolt (3)} &= Qc = \frac{Wac}{2b^2 + c^2 + 2d^2} \\
S \text{ for bolts (2) and (4)} &= Qd = \frac{Wad}{2b^2 + c^2 + 2d^2}
\end{aligned}\right\} \qquad (3)$$

From the foregoing sets of formulas (2) and (3), the values of S'_s and S may be readily ascertained by observing the following rule: First ascertain the possible axis of rotation of the bracket as a whole and the center of gravity of the bolts. Then divide the moment of the weight W about this center of gravity, by the sum of the squares of the distance of each bolt from the axis of rotation, and finally multiply the result by the distance to this axis (or center), from the bolt under consideration.

Since the two shearing stresses S_s and S'_s are acting in the same sectional plane, they will combine in one resultant force S_{sr} for each bolt, as shown by the diagram Fig. 2. In other words, each bolt is under the influence of but two forces, the tension force S and the resultant force S_{sr}; therefore, remembering that S and S_{sr} are acting perpendicular to each other on every particle in the cross-section of the bolts, their maximum combined effect P_1 in tension and P_2 in shear may be found by the well-known formulas for circular section bars:

$$P_1 = \tfrac{1}{2}\,(S + \sqrt{S^2 + 4S^2_{sr}}) \qquad (4)$$

$$P_2 = \tfrac{1}{2}\,\sqrt{S^2 + 4S^2_{sr}} \qquad (5)$$

The determination of the total combined stress to which the bolts are subjected consists simply of substituting in the foregoing fundamental formulas the respective values for tension stress and resultant shear stress.

Example Illustrating Application of Formulas

A numerical example will graphically illustrate the application of the foregoing principles. Assume that the weight W is 12,000 pounds; the diameter of the bolts ⅞ inch; and that $b = 5\frac{1}{2}$ inches, $c = 3\frac{1}{2}$ inches, $d = 1\frac{1}{2}$ inches; also b_1, c_1, d_1, and $e_1 = 6\frac{1}{4}$ inches each; $a = 4$ inches and that $a' = 10$ inches.

By substituting in Formula (1)

$$S_s = \frac{12{,}000}{5} = 2400 \text{ pounds}$$

and from Formula (2)

$$S'_s = \frac{12{,}000 \times 10 \times 6.25}{4 \times 6.25^2} = 4800 \text{ pounds for each bolt.}$$

From the diagram Fig. 2, the resultant shearing force S_{sr} for bolts (1) and (2) = 2500 pounds; and for bolts (4) and (5) = 7200 pounds. Now, since the cross-sectional area of a ⅞-inch bolt is 0.6 square inch, the unit shearing resultant stress for bolts (1) and (2) is 2500 ÷ 0.6 = 4166 pounds per square inch; for bolt (3), 2400 ÷ 0.6 = 4000 pounds per square inch; and for bolts (4) and (5), 7200 ÷ 0.6 = 12,000 pounds per square inch. Having found the resultants of the two shearing forces, the tension stress S is found by substituting in formulas (3) as follows:

For bolts (1) and (5),

$$S = \frac{12{,}000 \times 4 \times 5.5}{2 \times 5.5^2 + 3.5^2 + 2 \times 1.5^2} = 3421 \text{ pounds}$$

For bolt (3),

$$S = 3.5 \times 622 = 2177 \text{ pounds}$$

For bolts (2) and (4),

$$S = 1.5 \times 622 = 833 \text{ pounds}$$

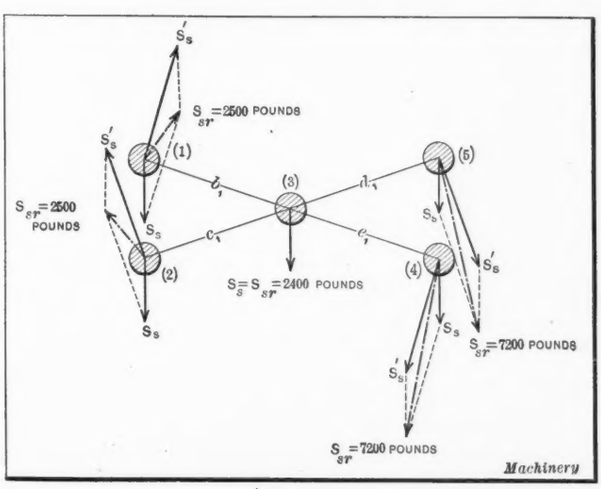


Fig. 2. Parallelogram of Force Diagrams, showing Resultant Shear Forces produced by Application of Load shown in Fig. 1

The unit tensile stress for bolts (1) and (5) is 3421 ÷ 0.6 = 5700 pounds per square inch; for bolt (3), 2177 ÷ 0.6 = 3630 pounds per square inch; for bolts (2) and (4), 833 ÷ 0.6 = 1380 pounds per square inch.

Having now determined the unit stress values for tension and shear, the maximum unit tensile stress p_1 and unit shearing stress p_2 for each bolt may be determined by employing the fundamental equations (4) and (5), as follows:

Unit Stresses in Pounds per Square Inch

Bolt (1)

$$p_1 = \tfrac{1}{2}\left[5700 + \sqrt{5700^2 + 4\,(4166^2)}\right] = 7900$$
$$p_2 = \tfrac{1}{2}\sqrt{5700^2 + 4\,(4166^2)} = 5050$$

Bolt (2)

$$p_1 = \tfrac{1}{2}\left[1380 + \sqrt{1380^2 + 4\,(4166^2)}\right] = 4910$$
$$p_2 = \tfrac{1}{2}\sqrt{1380^2 + 4\,(4166^2)} = 4220$$

Bolt (3)

$$p_1 = \tfrac{1}{2}\left[3630 + \sqrt{3630^2 + 4\,(4000^2)}\right] = 6200$$
$$p_2 = \tfrac{1}{2}\sqrt{3630^2 + 4\,(4000^2)} = 4390$$

Bolt (4)

$$p_1 = \tfrac{1}{2}\left[1380 + \sqrt{1380^2 + 4\,(12{,}000^2)}\right] = 12{,}710$$
$$p_2 = \tfrac{1}{2}\sqrt{1380^2 + 4\,(12{,}000^2)} = 12{,}020$$

Bolt (5)

$$p_1 = \tfrac{1}{2}\left[5700 + \sqrt{5700^2 + 4\,(12{,}000^2)}\right] = 15{,}180$$
$$p_2 = \tfrac{1}{2}\sqrt{5700^2 + 4\,(12{,}000^2)} = 12{,}330$$

The foregoing results show that the bolts upon which the greatest strain is exerted are (4) and (5), while the bolt which sustains the least strain is (2), which emphasizes the importance of carefully calculating the stresses to which fastenings may be subjected.

* * *

INADEQUATE SALARIES OF PATENT OFFICE EMPLOYES

It is almost inconceivable that there are positions in the United States Government requiring highly trained men that pay a salary of only $200 more per year than they did seventy-two years ago. However, such is the case with the positions of examiners, assistant examiners, and clerks in the Patent Office, according to data prepared by Frank L. Walker, Dayton, Ohio. Examiners or assistant examiners must have a liberal general education, and in addition they must be either highly trained engineers, chemists, lawyers, mechanical experts, or specialists in industrial or technical lines. Questions that are encountered and which must be answered by the men holding these positions involve law and technology, and if an error is made in the decision of an examiner due to his lack of knowledge of these subjects, the manufacturer or inventor applying for a patent may later be involved in a long and expensive law suit in order to protect his interests. Thus it will be seen, that the qualifications for work of this nature are of a very high order.

It would seem that positions which require men with such an education and ability would pay a reasonable salary, but the fact remains that the salaries of primary examiners, who are the highest paid examiners in the department, is only $2700 per year. The salary of this position was $2500 per year in 1848, while the salary of an assistant examiner was $1500 per year. The salary of a fourth assistant examiner still remains $1500 per year, the salaries of the other grades of assistant examiners ranging between this and the salary of a primary examiner. Skilled clerks who are responsible for the important records of the department only receive from $720 to $1000 per year. In 1836, when the examining system of the Patent Office was inaugurated, a member of Congress received $8 per day for each day of attendance in Congress; district judges received from $1000 to $1800 per year; and examining clerks in the Patent Office received $1500 per year. The salaries of the latter were increased to $2500 per year in 1848. In 1870 a member of Congress received $5000 per year; district judges received $3500 per year, while primary examiners in the Patent Office received $2500 per year. Today a member of Congress receives $7500 per year and district judges $6000 per year, while primary examiners receive only $2700 per year, the salary of this position having been raised $200 in 1908.

From the foregoing it will be seen that the salaries of members of Congress and district judges have kept pace with the increased cost of living and salaries paid to men in positions requiring similar education and intelligence. The salary of the position of primary examiner, however, is only 8 per cent greater than it was in 1848. It is, of course, impossible for the highest efficiency of any department or organization to be maintained under such unsatisfactory circumstances, and the result in the Patent Office is that valuable men are resigning their positions in order to accept other positions which, although requiring less education and ability, pay a more attractive salary. It is evident that these vacant positions cannot be refilled with men equally qualified on account of the low salary, and there is danger of the Patent Office organization becoming thoroughly disorganized. There is at present a bill pending in Congress to remedy this unfair condition, and it is essential to the welfare of all industries that this measure be passed. Upon the efficiency of this department depends the rapid and lawful granting of patents to the mechanical, chemical, textile, and food-producing industries for labor-saving devices, which mean increased production.

Indicating and Contour Gages

By JOHN E. COLLINS

INDICATING gages, in which the indications are read off by sight, may be divided into five classes: (1) The dial and needle type. (2) Gages employing micrometer screw attachments. (3) Gages having a cross-hair microscope, usually in connection with a micrometer screw. (4) Signal lamp gages. (5) Multiplying-lever type indicators.

Dial Indicators

Dial gages usually employ a train of gears for multiplying the travel of the needle. Sometimes merely a large quadrant meshing with a small wheel carrying the needle is used. Nearly all dial gages have the general appearance of a watch, being usually mounted in a pressed-steel body. Some inspectors discourage the use of the dial type of gage, because of the backlash that develops in the gears when worn, the fluctuations of the needle due to the unbalanced action of the moving parts, and the unequal wear of the different moving parts. This unequal wear is caused by using a gage for gaging one size or one dimension for a long period of time. The fluctuations of the needle retard the inspection of parts, and for this reason the gage is often avoided when high speed is required in inspecting.

Micrometer Screw Type of Gage

The micrometer screw has been applied to many different types of gages because of certain advantages inherent in gages so constructed for work that cannot be easily inspected by a regular snap or plug gage. A micrometer screw may be considered accurate to at least 0.0001 inch, but it must be inspected for wear and to ascertain that the measuring point of the screw and gage are parallel with each other.

Cross-hair Microscopes

The cross-hair microscope is often used in connection with the micrometer screw, and it enables the inspector to obtain very accurate measurements. This attachment is often used for inspecting plug thread gages, but only a limited number of shops use this type of instrument, as it seems to be considered a laboratory appliance only.

Gages Equipped with Electric Signal Lamps

Gages equipped with signal lamps may be of various designs, but are usually built on the plunger principle. A flat surface plate is mounted under two sliding pins which are the "Go" and the "Not Go" points. These pins are connected with dry-cell batteries and are the terminals for one end of the circuit, the surface plate being the other terminal. A colored electric lamp, usually red, is connected with a "Not Go" plunger and a green lamp, with a "Go" plunger. The work is first slid under the "Go" plunger, and if no green light shows it is of the correct size as far as the "Go" operation is concerned. The work is then slid under the "Not Go" plunger, and if the red light shows it indicates that the work is of the correct size.

This class of gages will give very accurate results, and may be used to gage as close as 0.0001 inch. Care must be exercised, however, not to connect the lamps with too strong a battery, for in that case the spark is likely to "jump" the slight distance between the gaging plunger and the surface of the work.

Multiplying-lever Gages

Multiplying-lever gages have several disadvantages, and should not be used in taking measurements requiring great accuracy. The greatest objection to this type of gage is the weight of the moving arms, etc. This condition can sometimes be relieved by the correct proportioning, arrangement, and balance of the various units of the lever. Another disadvantage is the large number of wearing points which necessitate frequent inspection of the gage itself to determine its accuracy. All gages of this type should have a "check" for discovering the wear in the gage itself. The leverage ratio should be 100 to 1 and in no case less than 50 to 1, as this ratio provides for only about 1/16 inch graduations for each 0.0001 inch variation in the work.

Indicator Concentricity Gage

An indicator concentricity gage, which is used for gaging cylinders and other similar work, is illustrated in Fig. 1. It consists of the cast-iron base *A*, a long arm *B* which swings on a boss cast on the base, and the indicating arrangement. The arm *B* is so arranged that the work may be placed in position for gaging without disturbing the setting of the indicator. The cycle of operations necessary for gaging a piece of work consists of raising the indicator pin by means of the knurled nut *F* and swinging the arm *B* back into position; then by turning the work around, its concentricity may be determined by means of the indicator arm. Adjustment of the knurled nuts *H*

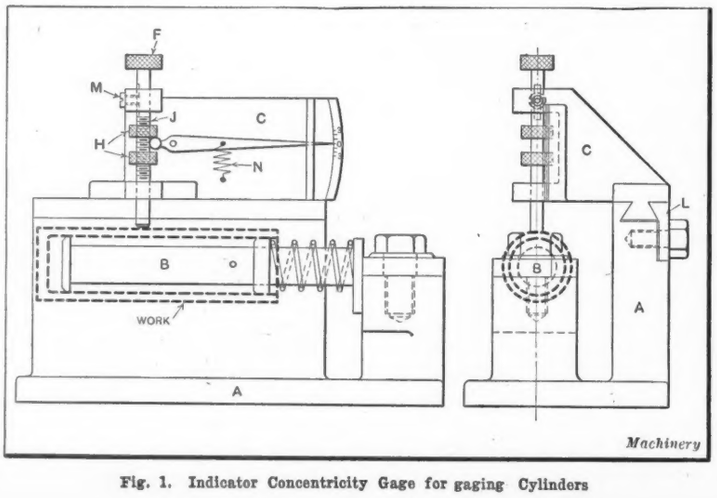


Fig. 1. Indicator Concentricity Gage for gaging Cylinders

will bring the indicator arm into the zero position. A set-screw *M* fits the keyway in screw *J* and prevents it from turning. An inspection of the end view will show that arm *C* is fitted in a dovetail groove in the base *A*, in which it slides to adjust the position of pin *J* longitudinally along the work, after which it is secured in position by means of clamp *L*. All parts except the spring, base, and arm *C* are made of machine steel and are pack-hardened. By designing rollers to take the place of the arm *B*, solid cylindrical work may be inspected on this gage without otherwise changing the design.

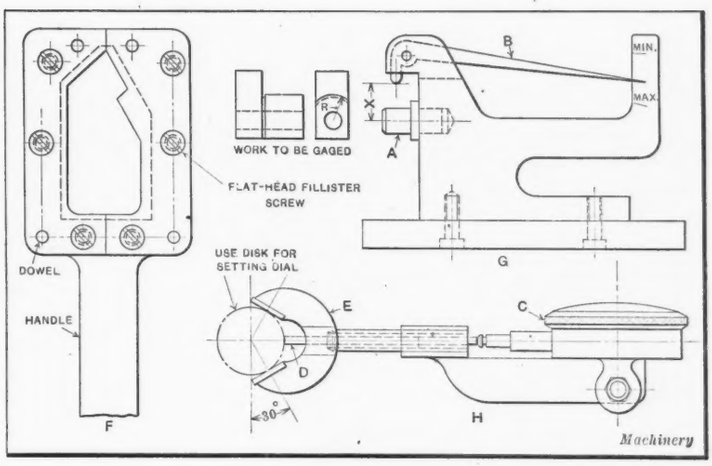


Fig. 2. Outline and Radius Gages

Radius Indicating Gage

The gage shown at *G*, Fig. 2, is designed to inspect work the radius *R* of which is located from the center of a hole. The gage is very simple, the work being slid on the locating arbor *A*, with the bearing point of the indicator *B* resting on the surface to be gaged. Then by slowly turning the work from one extreme point to the other and at the same time observing the position of the indicator point, it may be readily determined whether or not the radius is within the two extreme limits which are allowed on the work. These limits are established by minimum and maximum lines etched on the gage as shown, but if the gage is used as a working gage, another line should be etched midway between these two to represent the ideal conditions, and the operator should work to this line. The gage proper is mounted on a square block so that it may be moved from bench to bench as desired.

Three-point Indicating Gage

The gage shown at *H*, Fig. 2, was designed for use in gaging cylindrical work while it is being rotated. Experience has shown that these gages give the best results on ground work and that the unevenness of turned work causes the needle to fluctuate so that it is impossible to take an accurate reading. Referring to the illustration, *C* is the dial indicator and *D* the gaging pin, which is hardened and lapped and which rests against the work. The gaging pin is centered on the work by the 60-degree V-block *E*, the two hardened and lapped surfaces of which are in contact with the work as it is revolved and gaged. This gage must have a check, a hardened and ground disk of the same diameter as the work being employed for setting the dial before the work is gaged.

Depth Measuring Gage

Another type of indicating gage in which the flush-pin gage is converted into a dial gage is illustrated in Fig. 3. This gage is used for measuring the depth of a bore or the distance of a boss face below the surface from which the measurement is taken. The measuring rod, which may be of any desirable length, is shown at *A*, while *B* represents the bearing body which also supports the spring for the flush-pin. *C* is the bar which rests on the gaging surface, and *D* the indicator support pin. The greatest use for a gage of this type is on milling operations, it being used either as a working or inspection gage. In all cases the gage should have a check to set the dial by, so that the operator can inspect the accuracy of the gage before using it. However, for the inspector's use, a common flush-pin gage would be the most efficient, because the inspector is interested only in whether or not the part is within the limits, and not in the amount that it is over or under these limits.

Gages for Inspecting Irregular Outlines

The receiving gage is a type that is very useful for inspecting irregular outlines of parts, where a very accurate result is not required, the work being considered correct if it passes through the gage. The construction of the receiving gage is very simple, as will be seen by referring to view *F*, Fig. 2. The handle and the support for the gaging plate are made in one piece. This piece has an opening, as shown by the dotted line, of sufficient size and proper shape so that clearance is provided for the work as it is passed through from the top of the gage. The top is made of two pieces which are held in place by means of dowel-pins and screws, as shown. As the gage becomes worn it may be reset by relocating the dowel-pin and screws and adjusting the top plate to the required position.

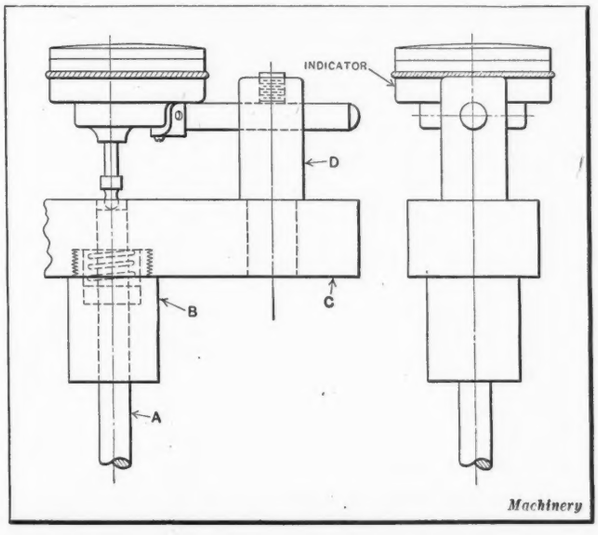


Fig. 3. Dial Type of Depth Measuring Gage

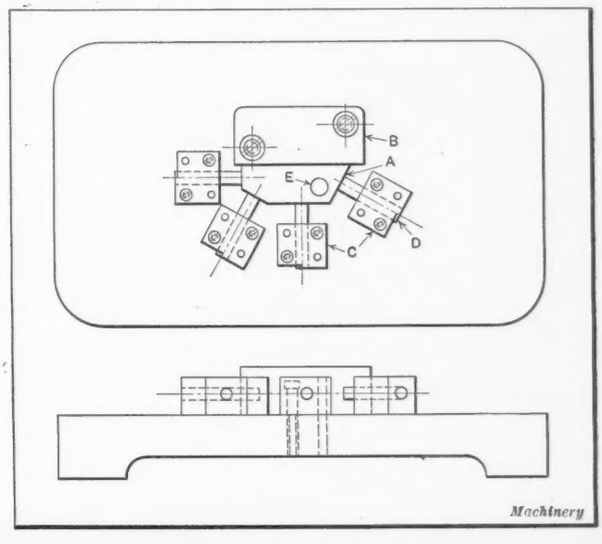


Fig. 4. Flush-pin Type of Profile Gage

The ordinate method of gaging is considered very accurate for use on irregular outlines or profiles. One method of taking measurements by this system employs common flush-pin gages, which are set at the most important points around the profile of the part to be gaged. This type of gage is outlined in Fig. 4, in which the part to be inspected is represented by *A*, and the block against which the work is lined up for gaging by *B*. The blocks *C* carry the flush-pins *D*, while *E* is a pin which is used to locate the work in its correct lateral position. If the limits on the work are known, it is obviously an easy matter to make flush-pins having these limits and to set them in their correct position in relation to the work. In laying out gages of this kind, care must be taken to locate the important points, such as flats and high spots, on the part to be gaged. The flush-pins should be laid out at right angles to flat surfaces, and if located at a corner, the center line of the pin should bisect the angle formed by the two surfaces.

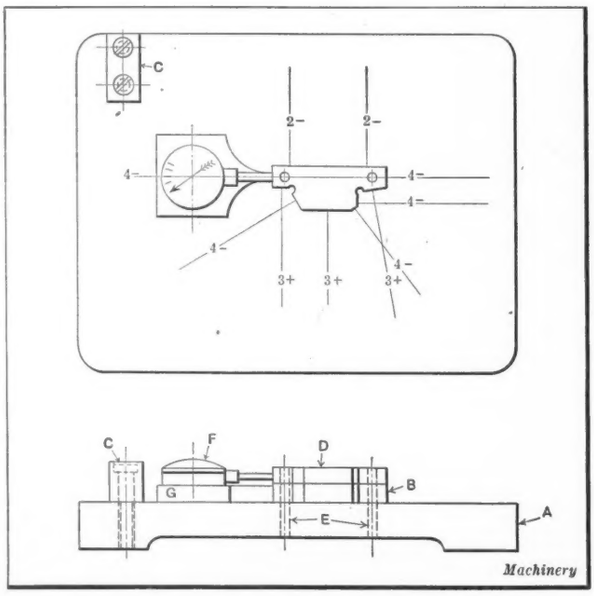


Fig. 5. Indicator Type of Profile Gage

In Fig. 5 another type of gage is shown which employs the ordinate method in connection with a dial indicator. This is often used when the points to be gaged are not accessible with the flush-pin type of gage. The gage consists of a surface plate *A*, on which is mounted a master profile *B*. The master profile should be hardened and lapped to the exact size and outline of the part to be gaged, that is, to its mean dimensions. A hardened, ground, and lapped block *C* located perpendicular to the surface of plate *A*, is used to set the dial indicator, as will presently be explained. The work *D* to be gaged is located in the correct position by means of the pins *E*, which also serve to fasten the master on the surface plate. The dial indicator *F* is securely fastened to the hardened block *G*. The surface of this block resting on block *A* should be ground and lapped, as well as the end surface which bears against the master profile. Of course all work will not have holes which may be used for locating, and in that case, other suitable means must be devised, such as allowing the work to rest against a surface on the side of the piece and gaging on the opposite side, as in Fig. 4.

When using a dial indicator, limits or tolerances on the work must be established in their correct direction. The method of procedure is to place the work directly over the master, which has previously been located in the center of the surface plate. The point of the indicator must be in perfect alignment with the end surface of the holding block *G*, Fig. 5, when the indicator needle is set at zero. This condition is obtained by placing these two extremities against block *C* and adjusting the indicator needle while the block is in this position. With the point of the indicator stem directly above the point on the holding block, the block is then brought into contact with the master and the indicator point into contact with the work, so that it is possible to read off in thousandths of an inch any differences that may exist between the work and the master. The indicator holding block *G* should have a heavy vertical line inscribed on its rear side at the center. This is used to align the blocks and spindle of the indicator with the tolerance lines that are inscribed on the surface plate *A*. These lines on the surface plate are located similarly to the manner employed in placing the flush-pin in position, as described in connection with Fig. 4. The notations 4 —, 3 + and 2 —, in Fig. 5, indicate, of course, the maximum and minimum limits that are allowed on the work at the points indicated.

Snap Plate Gages

Fig. 6 illustrates a type of combination gage that has been developed exclusively for gaging work which is too small to be held conveniently in the fingers. The gage is intended for use on large quantities of work of the type shown in the illustration. The baseplate *B* is ground on its top surface, the guide plate *A* being attached to it, so as to guide the work between the "Go" and the "Not Go" snaps *C*. These snaps should be provided with checks to be used in inspecting the gage for wear. A section of the large guide block *A* is milled out at *E* to allow finger space for pushing the accepted work to one side of the plate. Rejected pieces will pass through the "Not Go" snap, off the plate. This plate is made of sufficient size to accommodate a handful of pieces, so that they may be rapidly inspected by passing them through the runway formed by plates *A*.

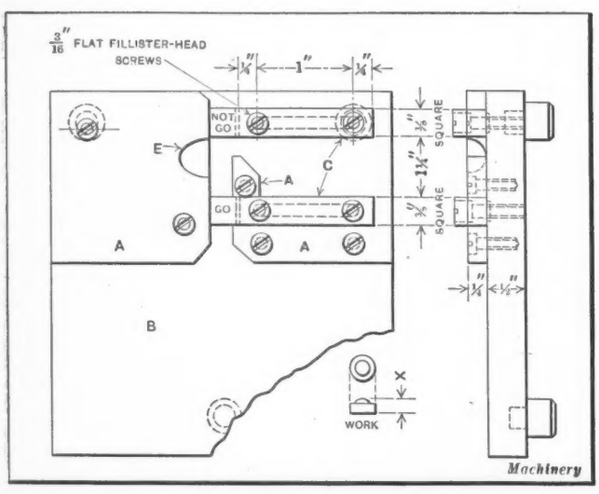


Fig. 6. Snap Plate Gage for gaging Small Work

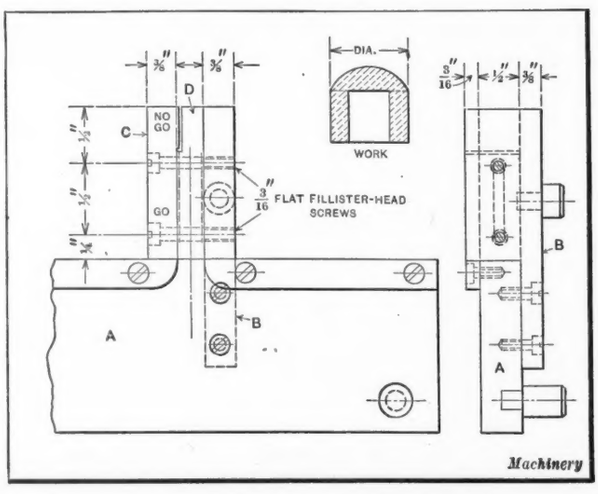


Fig. 7. Snap Plate Gage for gaging Diameters

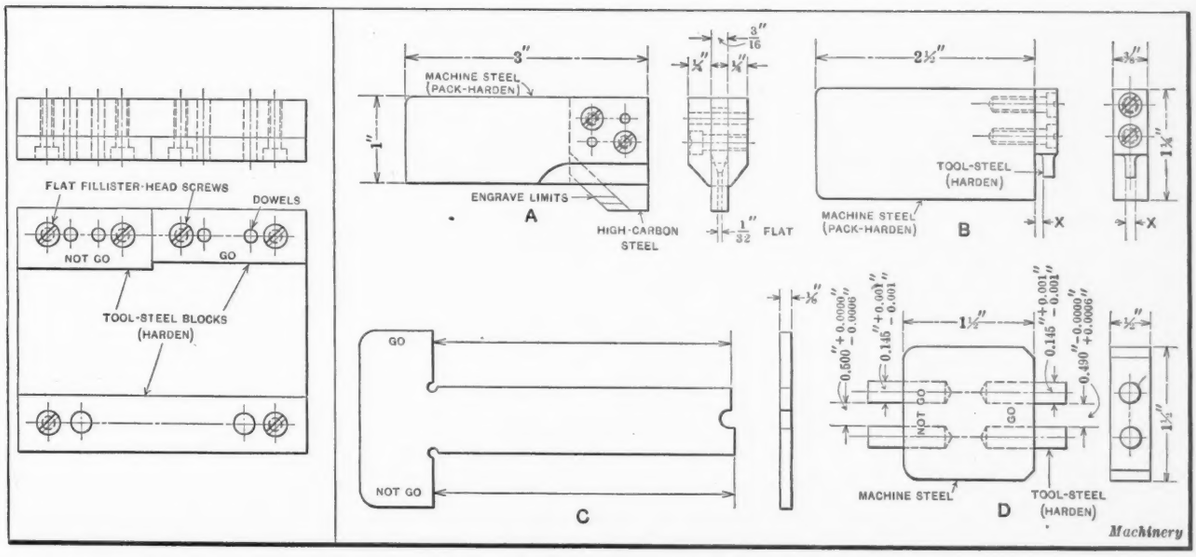


Fig. 8. Bar Type Gage for gaging Diameters

Fig. 9. (A) Gage for testing Bevels. (B) Hole or Groove Locating Gage. (C) Gage for gaging Lengths. (D) Pin Gage for gaging Grooves and spacing Holes

Another special type of snap plate gage and the work for which it was designed are shown in Fig. 7. This gage is intended for inspecting diameters only. The flat plate *A* acts as a table to hold a number of parts at a time. The long narrow piece *B* extends back under the plate *A* and is held to it by means of two screws. Parts *C* and *D* are fastened with screws to *B*, thus holding the complete gaging unit to the base. A few dimensions are given in the illustration so that an idea of the proportion of the gage may be obtained. A piece of work is slid on the plate *A* into the gage; if it passes through both the "Go" and "Not Go" sections it is, of course, rejected, but if having passed the "Go" snap, the part fails to enter the "Not Go" gage it is accepted.

The bar type of gage is designed to supersede the snap gage for inspecting diameters that are measured near the end of the work, the end being flat and bearing on the plate of the gage. This type of gage, which is shown in Fig. 8, is especially adapted for use on flat work, such as ground disks. The "Go" and "Not Go" gage-plates may be relocated to compensate for wear, which involves careful resetting of the blocks.

Unclassified Gages of Various Designs

Bevel Gage—This gage is used for testing bevels, etc., which are dimensioned from a finished surface at the end or side of the work. As may be seen by referring to *A*, Fig. 9, the "built-up" type is used where the chamfer must be tested along its entire length, that is, to the extreme point on both sides of the work. On account of the relief which must be provided for grinding purposes, a "built-up" gage is preferable to the plate type. Limit lines should be engraved on the gage after assembling, as shown in the illustration. The body is beveled to allow free inspection of the work when gaging.

Hole or Groove Locating Gage—A very good design of gage for inspecting the distance of a hole from a finished edge or surface is illustrated at *B*, Fig. 9. The gaging post is made of hardened tool steel and the body of machine steel, pack-hardened. The construction is simple and should be readily understood from the illustration.

Length Gage—At *C* is shown a gage that is used for measuring straight lengths from a shoulder or from the beginning of a taper. In this type of gage, the shortest side is considered the "Go" gage, whereas the longest side would not go in any case if the work is correct. Tolerances for this gage should be applied in the same manner as for standard snap gages.

Pin Gage—The gage shown at *D* is used for measuring diameters of grooves on turned work, etc., as well as for the spacing of holes which must be within certain defined limits. The "Go" side of the gage is chamfered for identification purposes.

Thickness Gage—The gage illustrated in Fig. 10 is used to measure the thickness of walls, which are not accessible when using an ordinary snap or micrometer gage. It is also much cheaper to make than the gages which are sometimes used for gaging work of this nature, such as dial indicator gages, etc. The knurled handle *A* holds the shank of the feeler *C*, to which it is pinned, in such a manner that the feeler may be turned without disturbing the position of the leg *B* against the outer wall of the cylinder. Three-fourths of the boss on leg *B* is milled off and a pin inserted through *C*. The end of this pin rests on the projecting ring quadrant, formed by milling the boss of *B*, so that the feeler *C* may

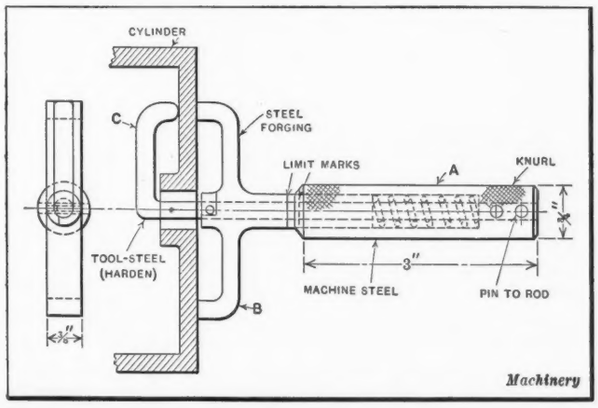


Fig. 10. Gage for measuring Thickness of Walls

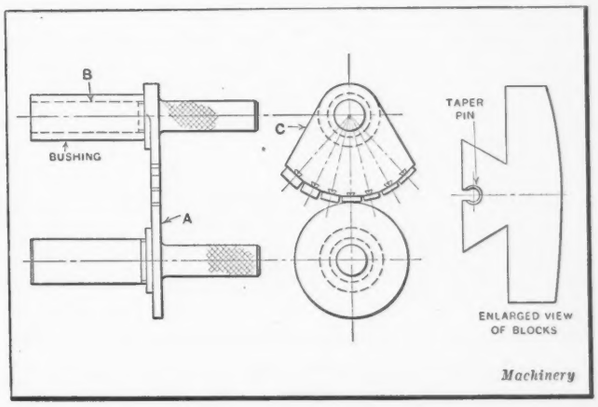


Fig. 11. Center Distance Gage for Spur Gears

be turned at right angles to the position shown in the illustration; and when handle *A* is pushed in, the coil spring in it will be compressed, thus removing *C* from contact with the inner wall of the cylinder and allowing the gage to be tilted and withdrawn from the work. The "Go" and "Not Go" limit lines are engraved on the shank of *B*, and the limits are determined at the beveled end of the handle, at which point any lateral movement of the feeler will be indicated.

Center Distance Gage for Spur Gears—The center distance of spur gears, which must be held to a limit, may be inspected with a gage such as shown in Fig. 11. This gage has removable wearing blocks, shown in the enlarged view, which are ground independently and to various radii. Each block is so ground that one side of its vertical center line represents the plus limits and the other side the minus limits. These plugs are inserted in the quadrant which holds them successively in the order of mean center distances, beginning at the smallest radius; they are also ground in this order while held in the gage body, so that the several radii are ground from the same center. The gage consists of an accurately ground collar *A*, which is pressed on a plug, and used in the center of one gear, the other center having a plug *B* with the block-holding quadrant *C* attached. Bushings may be used with the gage for increasing the center distances, and in all cases the plug which carries the contact blocks should have a bushing to take the wear caused by turning the quadrant when inspecting the work. The collar *A* is made circular instead of quadrant-shaped so as to give a longer wearing life. By making a set of bushings to fit both plugs, and a set of quadrants of various radii, a compact and complete set of center distance gages may be produced.

* * *

INSPECTING TAPERED FLAT GAGES

By V. E. AYRE

Referring to diagram *A* in the accompanying illustration, to find the distance *Y* from the shoulder to the intersection of the taper with the vertical, proceed as follows: First measure angle *b* on a sine bar. Then set the gage on an angle-plate with the surface, of which *Y* is the length, perpendicular to the surface plate. Clamp either a try-square or straightedge against this surface and drop in a wire of diameter *G*, as shown in the diagram. Measure *H*, the distance from the top of the wire to the shoulder, and finally from the above measurements calculate *Y*, thus:

$$Y = H - (L + g)$$
$$L = g \cot \tfrac{1}{2} b$$

Therefore

$$Y = H - (g \cot \tfrac{1}{2} b + g)$$
$$= H - g (1 + \cot \tfrac{1}{2} b)$$

Another method of determining the dimension is shown in the diagram *B*, in which the dimension is represented by *X*. In this case the straightedge is clamped to the end of the gage and dimension *L* is measured. Measure angle *b* on the sine bar, then clamp the gage to an angle-plate so that the surface at the tapered end of the gage is in a vertical position. Clamp a small parallel bar against this surface and drop in a wire of radius *g*, as shown by the full-line circle. Measure the distance *H* from the top of the wire to the surface of which *X* is the length, and from these measurements determine the depth *D* by the use of the following evolution of the formula $D = H + g + W$.

$$W = g \cot \tfrac{1}{2} (90 \text{ degrees} - b)$$

Therefore

$$D = H + g + g \cot \tfrac{1}{2} (90 \text{ degrees} - b)$$
$$= H + g [1 + \cot \tfrac{1}{2} (90 \text{ degrees} - b)]$$

If a large-diameter wire is used, as shown by the dotted circle,

$$D = g_1 + W_1 - H_1 = g_1 + g_1 \cot \tfrac{1}{2} (90 \text{ degrees} - b) - H_1$$
$$D = g_1 [1 + \cot \tfrac{1}{2} (90 \text{ degrees} - b)] - H_1$$

Having found the value of *D*,

$$X = L - Z$$

But

$$Z = D \cot b$$

Therefore

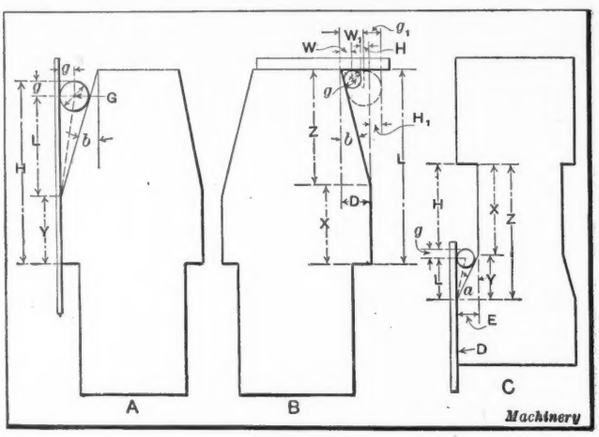
$$X = L - D \cot b$$

Diagram *C* illustrates the method of inspecting the check for the type of gage shown in the other two diagrams. To find length *X*, the distance from the shoulder to the beginning of the taper, first measure angle *a* on the sine bar, and the depth *E* with a depth micrometer. Set the check on an angle-plate with the surface at *D* perpendicular to the surface plate. Clamp a straightedge or try-square against surface *D* and drop in a wire of radius *g*. Then measure distance *H*, from the shoulder to the top of the wire. Calculate the distance $L + g$, from the given radius of the wire and the measured angle *a*, as follows:

$$L + g = g \cot \tfrac{1}{2} a + g$$
$$= g (1 + \cot \tfrac{1}{2} a)$$

and then find the values for *Y* and *Z*, thus:

$$Y = E \cot a$$
$$Z = H + (L + g)$$



Diagrams illustrating Methods of using Wires in checking Gages. Diagram (C) shows the Check for the Gages

Substituting for $L + g$,

$$Z = H + g (1 + \cot \tfrac{1}{2} a)$$
$$X = Z - Y$$

Therefore

$$X = H + g (1 + \cot \tfrac{1}{2} a) - E \cot a$$

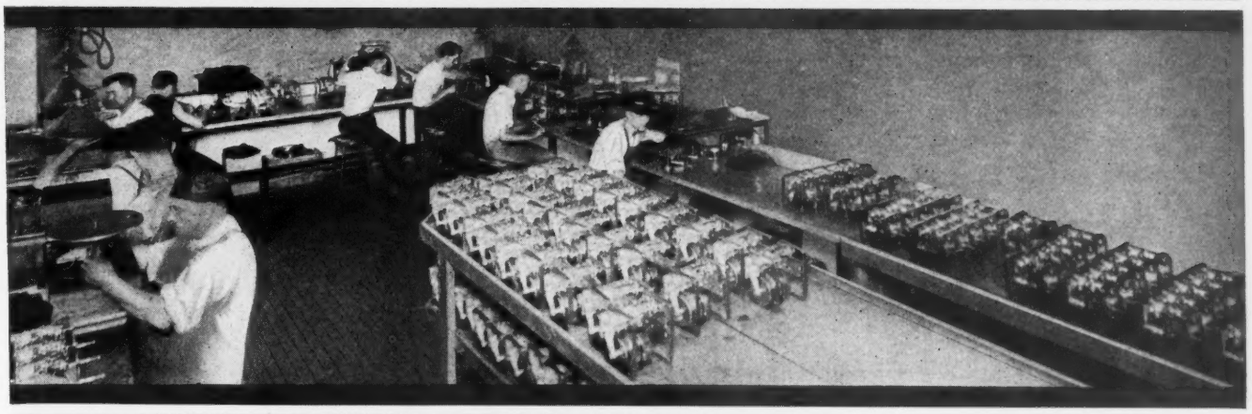
* * *

NATIONAL FOREIGN TRADE CONVENTION

The National Foreign Trade Convention called by the National Foreign Trade Council, to be held in San Francisco, May 12 to 15, will have as its general theme "The Effect of Being a Creditor Nation." The general object of the convention will be to analyze the conditions now confronting American international commerce, and those it will have to meet in the immediate future; to consider the influence of the results of the war upon our foreign trade; to study the effect of being a creditor instead of a debtor nation; and to endeavor to obtain the thoughtful judgment of American business men upon these problems of vital importance. Further information regarding the convention may be obtained by communicating with the secretary, National Foreign Trade Council, India House, 1 Hanover Square, New York City.

At the trade convention, about thirty foreign nations will be represented. The departure of the National Foreign Trade Council this year in extending an invitation to foreign countries to be represented by special trade advisors is expected to result in a notable attendance of foreign traders. Ten trade advisors are being allotted to each one of the foreign nations whose commercial representatives have been invited to the convention. These special advisors will be chosen by trade organizations in their respective countries.

Manufacturing Krasco Spring Motors



First of Two Articles Describing the "Krasco" Phonograph Motor and the Organization and Arrangement of the Krasberg Engineering & Mfg. Corporation's Plant

By EDWARD K. HAMMOND

OWING to the competition existing among different makers of phonograph motors, the manufacturer who expects a reasonable margin of profit must carefully organize his plant in order to obtain the maximum economy in using materials, and efficiency in handling the work. Visitors who are shown through the plant of the Krasberg Engineering & Mfg. Corporation in Chicago, contract manufacturers, designers and builders of special machinery and tools, will be impressed by evidences of the care which has been taken in perfecting the details of this firm's factory practice. Especial attention has been paid to the arrangement of the manufacturing departments, so that the work is routed in a continuous line from the receiving room through the various work-shops until the finished motors finally reach the department where they are packed for shipment to the consignee. This not only saves time in handling the work and thus reduces direct labor costs, but also cuts down the overhead expense which must be charged against each motor, because it increases the daily output of the plant.

Carrying the idea of efficient production to its logical conclusion many ingenious methods have been developed for the machining operations, which are responsible for effecting economies in the process of manufacture. Although these methods are described in connection with the manufacture of spring motors, most of them are applicable in plants engaged in the manufacture of a great variety of other products. For that reason, the present article becomes one of more general interest than would be the case if it were a mere description of the machinery and methods used in manufacturing a mechanical specialty; but in order to make clearer the reasons for certain practices which are employed, it will be desirable to first give a brief description of the "Krasco" spring motor.

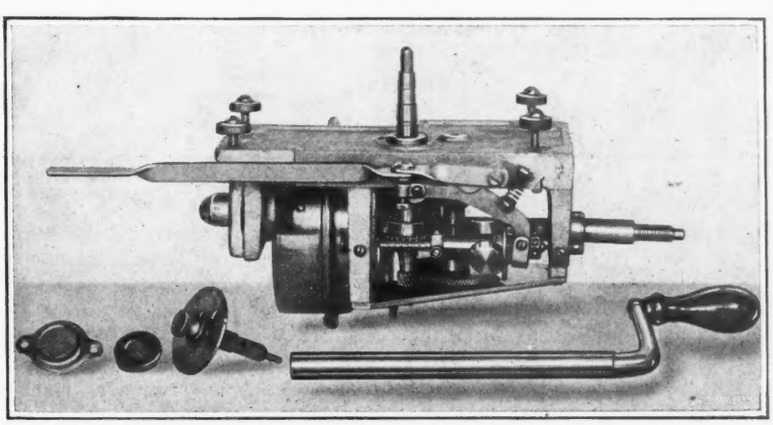


Fig. 1. Two-spring Type of "Krasco" Motor which develops Sufficient Power to play Three Ten-inch Records

The "Krasco" Spring Motor

Figs. 1 and 2 show two types of "Krasco" spring motors, and in starting to explain the way in which a motor of this kind operates it will doubtless be best to first call attention to the two opposite ends of the train of mechanism. At *A* Fig. 2, there is shown the spindle on which the record turntable is carried, the top of this spindle being machined to a taper which fits into a corresponding tapered socket in the hub of the table. The winding crank *B* makes connection with an arbor *C*, which transmits the crank motion to a train of gearing that winds up the springs. To meet the requirements of different phonograph manufacturers, motors are made in two-, three-, and four-spring types. Fig. 1 illustrates one of the two-spring motors, and in Fig. 2 a three-spring outfit is shown. The springs are contained in cases shown at *D*, in Fig. 2, and as the springs are wound up by crank *B*, a ratchet and pawl prevent them from running back. Then when the motor is started, its power is transmitted through bevel gears *E* and spiral gears *F* to the turntable spindle *A*. In order for a phonograph to be universally applicable for playing the great variety of music which is reproduced on an instrument of this kind, it is necessary to provide means of regulating the speed at which the record is rotated. For this purpose a controller dial *G* is provided, and by turning the indicator over this dial, movement is transmitted through link *H* to a sliding member *I*, which makes a suitable adjustment of the centrifugal controller *J*, that automatically governs the speed at which the motor rotates the record.

Organization of Manufacturing Departments

Mention has been made of the way in which the manufacturing departments are laid out in the Krasberg plant in order to reduce lost motion to a mini-

mum and thus increase the efficiency of the manufacturing operations. The same general principles are employed in laying out the manufacturing, assembling, and inspection departments; and as it is proposed to present detailed descriptions of some of the more interesting methods employed in performing machining operations, the part of this article dealing with the arrangement of departments will be confined to those which are engaged upon the inspection of finished parts and assembling of the product. This will give the reader a general idea of the way in which all three classes of operations are conducted. There are three floors of the Krasberg plant devoted to spring motor manufacture, which only represents a portion of the company's business. Whenever possible, power presses are used in making parts of the product, as this type of equipment is unusually well adapted for the attainment of rapid production. The press-room is located on the lowest of the three floors, and on the second floor space is given over to the various types of machine tools which are required for performing machining operations on various spring-motor parts.

The product from both the press-room and the machine shop is sent directly to the third floor, and when received at this point it first passes through an inspection room, a partial view of which is shown in Fig. 3. Here the various parts receive the necessary inspection to assure having each piece come up to the stipulated requirements of accuracy and perfection of workmanship. In planning both the process of manufacture and the performance of inspection operations, however, a great deal of thought has been given to the actual service which is performed by each motor part, and the requirements which must be fulfilled in making it, in order to assure having the part function properly. Obviously, it would be an unnecessary refinement to hold parts to limits of, say, 0.001 inch, where a more liberal limit of tolerance could be specified and still obtain the desired results. Care given this point has been the means of effecting substantial economies in the process of manufacture without in any way impairing the quality of the product. In fact, the study of proper tolerances constitutes one of the most important details of economical manufacture.

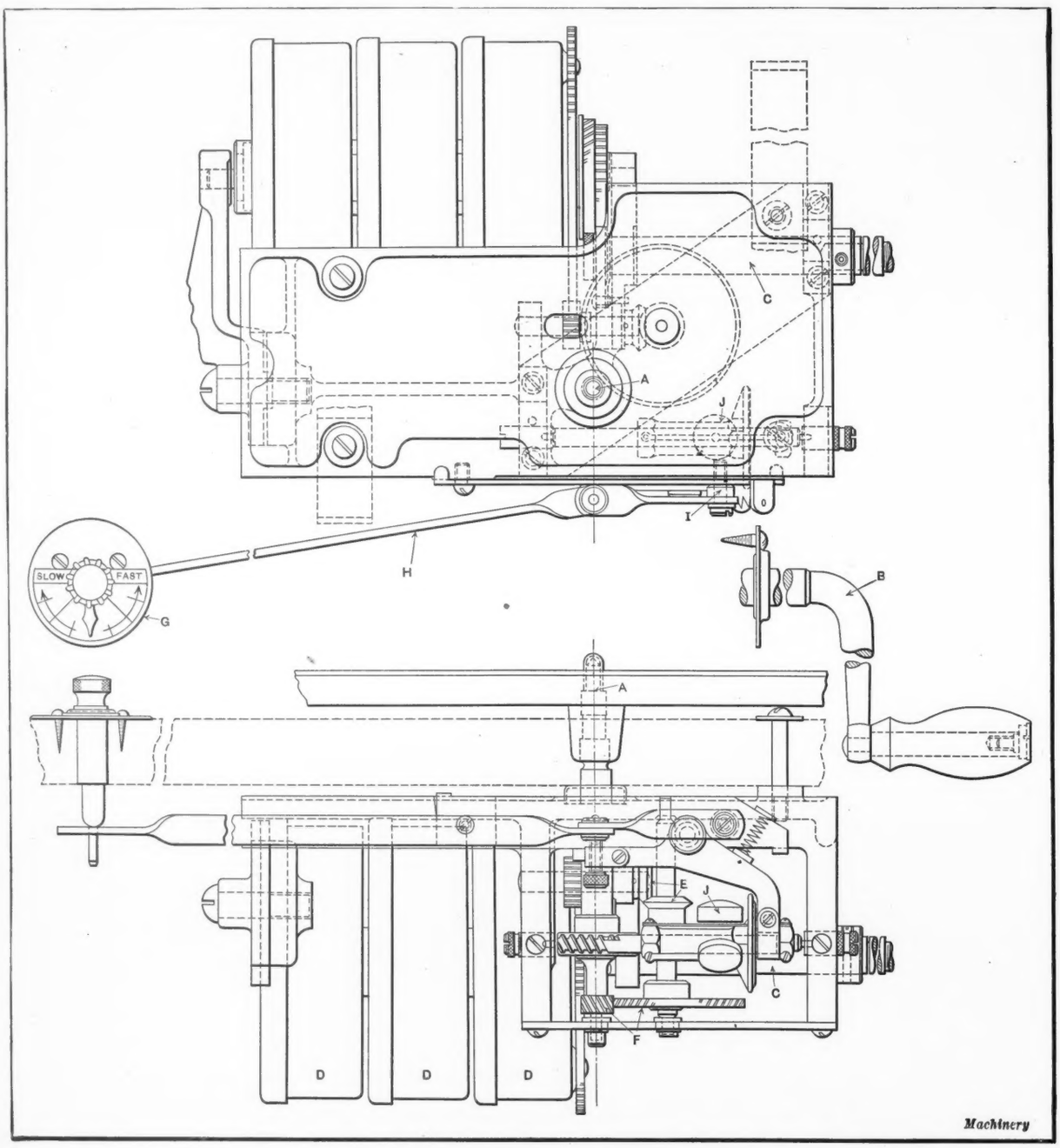


Fig. 2. Plan and Elevation of the "Krasco" Three-spring Phonograph Motor, illustrating its Principle of Operation

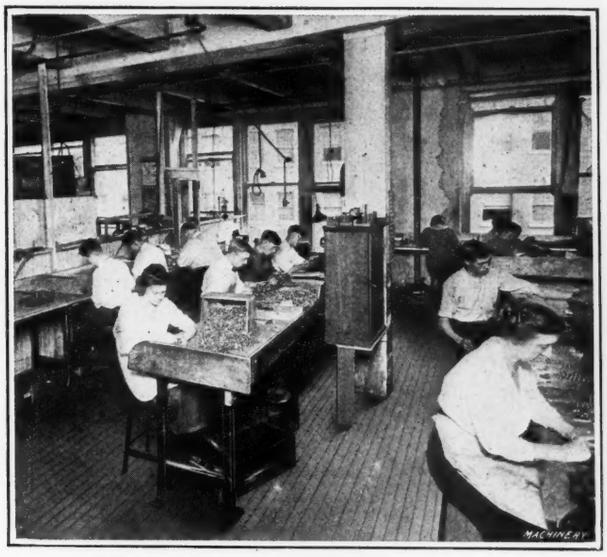


Fig. 3. One End of the Department where all Parts receive a Careful Visual Inspection before they are delivered to the Assembling Department

Fig. 4. A Partial View of the Spring Assembling Department. The Housing is packed with Grease to lubricate the Spring and prevent Rusting

Assembling Operations

Where properly applied, the so-called "unit" system of assembly is not only a convenience when it is required to make repairs on the product after it reaches the ultimate purchaser, but this principle also facilitates the actual work of manufacturing. It is employed in assembling "Krasco" spring motors, the procedure being to have groups of employes make up the different unit assemblies and then to send these units to the final assembling department, where they are put together to form complete motors. Fig. 4 shows a view in the department devoted to assembling the main spring units. This work involves assembling the spring in its case and packing the case with grease that serves the double purpose of lubricating the spring and protecting it from rust.

Progressive Assembly of Completed Motors

The so-called "unit" assemblies delivered to the final assembling department are distributed along transverse benches which are grouped in this department as shown in Fig. 5. Frames by which other parts of the mechanism are supported are delivered at the right-hand ends of these benches, and various unit assemblies are laid out along the benches in the order in which they are required by assemblers. Men working on this part of the process of manufacture take a frame and assemble a gear and shaft unit into place, this happening to be the first piece that is put in position. Then the spring motor frame is slid along the bench to the next man, who mounts the succeeding piece in place and then passes it along to the man at his left. With an arrangement of this kind, there is a continual stream of work going along each bench from right to left, and as each finished motor reaches the left-hand end of the bench, it is pushed off on a belt conveyor which runs along the left-hand end of the benches and carries the finished motors away to the testing department. It will be understood from the preceding description that all of the work of assembling a motor is done on one bench.

Testing Finished Motors

Before shipment, each motor is required to satisfactorily undergo a number of tests, in addition to which expert

Fig. 5. General View of the Assembling Department. Various Partial Assemblies of the Spring Motor are distributed along Transverse Benches, and the Work progresses from Right to Left along these Benches, Finished Motors being carried away by the Belt Conveyor at the Left-hand Side of the Department

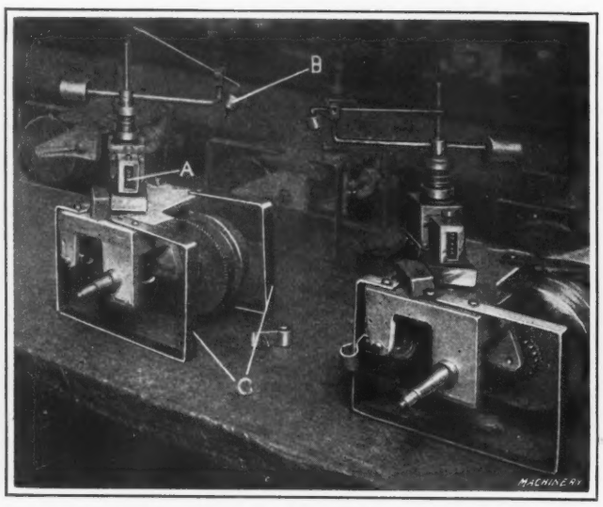


Fig. 6. Each "Krasco" Phonograph Motor receives a Running Test in Order to ascertain that all Parts of the Mechanism function properly

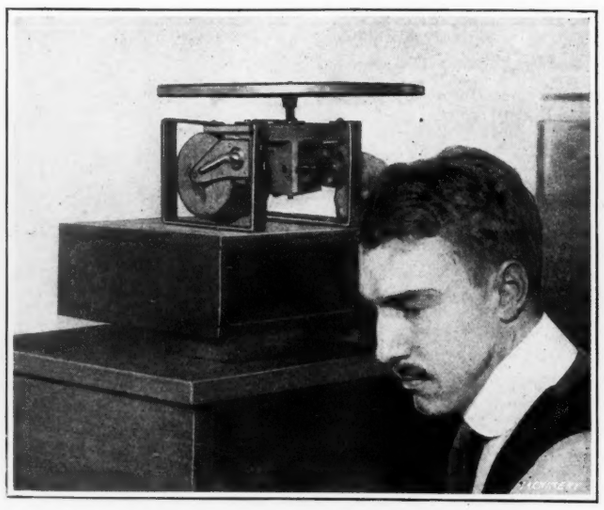


Fig. 7. Testing "Krasco" Phonograph Motor for Quiet Operation. Any Noise produced by the Motor would spoil the Effect in playing a Record

mechanicians observe the operation of each motor and make any adjustments which are found to be necessary. The first test required of the motors depends upon whether they are equipped with two or more springs. In the case of a No. 2 motor, it is required that after being fully wound up, the motor springs shall possess sufficient energy to drive the turntable through at least 750 revolutions at a speed of 80 revolutions per minute, which is equivalent to playing three 10-inch records. Similarly, a No. 3 motor is required to run through at least 1000 revolutions per minute at the same speed, which is equivalent to playing four 10-inch records. A No. 4 motor must make from 1500 to 1800 revolutions per minute at the standard speed, which is equivalent to playing from six to seven 10-inch records. Fig. 6 shows motors set up for conducting the power test. The fixtures used for this purpose are provided with a tapered socket which fits over the nose on the turntable spindle. On each of these fixtures there is an automatic counter *A* that records the number of revolutions made by a motor, and a pivoted indicator which has a counterweight *B* at one end.

When the motor is running at the specified speed of 80 revolutions per minute, there will be sufficient centrifugal force acting upon weight *B* so that the arm of the indicator will be in a horizontal position, as shown at the right-hand side of Fig. 6; but as the springs of the motor relax and approach a condition where the motor is "running down," the speed slackens sufficiently so that centrifugal force will no longer hold the indicator horizontal; instead the indicator will assume the position shown at the left in the illustration. Immediately an indicator arm rises in this way, the girls in charge of the testing bench observe the number of revolutions which the motor has made, and if this number is below the specified limit for the particular type of motor, the cause of the trouble must be corrected. All motors which pass the power test are passed along to a department where final adjustments of the mechanism are made, and "sound" tests are conducted in order to make sure that the motor will not be noisy while in operation.

Fig. 8. Each Motor is packed for Shipment in an Individual Carton, and Twelve Cartons are crated together for Delivery to the Consignee

Conducting the Sound Test

Very little thought need be given to the subject in order to make it apparent that a spring motor which is to give satisfactory service on a high-grade phonograph must run quite noiselessly, for the effect in playing fine records would be ruined if there were any perceptible noise made by the motor. For use in testing the perfection of the motors, in so far as freedom from noise is concerned, use is made of what are known as "sound boxes," on which the motors are placed, as shown in Fig. 7. These sound boxes are made of thin wood and have their joints carefully matched so that each box is completely closed on all sides except at the front. The motor to be tested is placed on the top of the box and allowed to run while the operator places his ear close to the opening at the front of the box. If the motor makes any noise while running, the vibrations which cause this noise will be imparted to the thin top of the sound box. This effect will be magnified by vibrations set up inside the box, thus enabling the man conducting the test to detect noises of such slight magnitude that they could not be heard with the motor standing on an ordinary work-bench. Where a motor does not give satisfactory results from the findings of this sound test, it is necessary to carefully inspect all parts of the mechanism and make the required adjustment to remove the cause of vibration that is responsible for the objectionable amount of noise that is produced when the motor is in operation.

Packing Motors for Shipment

When the work of assembling each motor is completed, two rectangular-shaped bands of iron shown at *C* in Fig. 6 are screwed on the motor frame by means of screws entering tapped holes in the top face of the frame. These two bands of iron serve as supports for the motor during the time that it is receiving power and sound tests, and they are left in place when the motors are transferred to the shipping room. The reason for this practice will be obvious by referring to Fig. 8, where it will be evident that each motor is packed in an individual strawboard carton. The two

bands of metal form a regular outline for the motor so that it slips into place in the carton and is not likely to be damaged in transit to the plant of the consignee. Twelve of these cartons are crated together for shipment, as shown at the right-hand side of the illustration.

Time-saving Methods of Performing Machining Operations

A general description has now been given of the arrangement of departments in that section of the Krasberg Engineering & Mfg. Corporation's plant which is devoted to the production of phonograph motors. Particular emphasis has been laid upon the coordination of the work of different departments, and upon methods of handling the product, which tend to save time and reduce production costs. To supplement the general description of the methods of factory management which are employed by this firm, a detailed description will be presented in the May number of some of the more interesting methods which are used in machining phonograph motor parts.

* * *

IMPORTANCE OF USING LEGIBLE BLUEPRINTS

By JOHN A. MARKSTRUM

Anyone engaged in the manufacture of parts produced according to blueprints made from pencil tracings, is constantly confronted with the problem of reading more or less illegible prints. If the dimensions are not discernible it involves consultation with the drawing-room, which means an unnecessary loss of time. If an error is made through guessing at the probable meaning of the illegible figure, it may result in the scrapping of the machine part and an additional loss caused by holding up production. If the part is being made for an out-of-town customer and the figures on the blueprint are not sufficiently clear so that they can be interpreted, due to the carelessness of the draftsman or the condition of the tracing, a series of communications between the two concerns will necessarily follow. These usually result in considerable delay and represent an unnecessary waste of energy. A common mistake is made by manufacturers in using worn out tracings having the pencil marks obliterated by frequent handling, patches covering important parts, corners torn off, or holes and creases destroying the very dimensions or views desired.

The following experience of the writer is an example of the uneconomical methods sometimes resorted to in order to eliminate the making of a new tracing. A prominent automobile company sent out an order for a small but intricate tool, the blueprints being made from a tracing which had been used so often that the lines and figures produced on the print were too faint to give any information. However, instead of having a new tracing made, the entire tool had been inked in on five copies of these worthless prints. It was the opinion of the writer that this was done in order to get prints ready without much delay, but a duplicate order was received a few days later accompanied by five more of these inked-over prints. The time required to ink in these ten copies was much more than would have been necessary to make a new pencil tracing, and still the firm was without a tracing for future use.

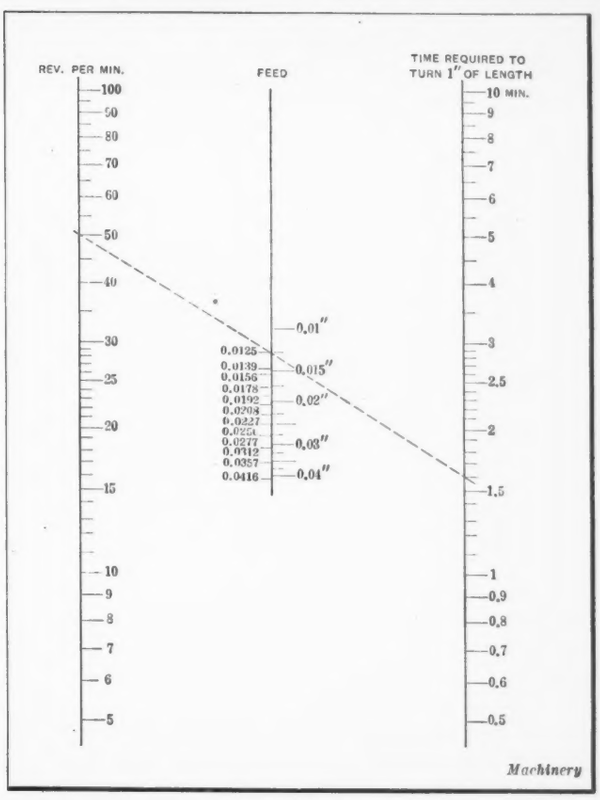
A shortage of draftsmen is generally given as an excuse for using poor tracings, but it is the opinion of the writer that a good method to train inexperienced men to be draftsmen would be to have them reconstruct or re-make the tracings which will no longer produce a good print. It is a known fact that good blueprints can be made from good pencil tracings and so there is no excuse for any poor prints. The importance of skilled labor is appreciated more today than it ever was, and many precautions are taken to safeguard the health and efficiency of employes, but through gross neglect this efficiency is often decreased and the eyesight of the workman impaired by the use of illegible blueprints. Needless to say, this condition should be remedied.

TIME CHART FOR LATHE TURNING

By L. deL BERG

In the November number of MACHINERY, page 268, a chart was shown in connection with the article "Chart for Estimating Turning Time." The principal objections to the use of a chart of this kind for lathes or similar turning work, are that each individual speed requires a separate curve and that if several speeds are laid out on the chart they are very likely to come close together, and cause confusion.

These objections may be easily overcome by using a straight-line logarithmic chart, such as illustrated in this article. From such a chart, any desired turning time can be determined, for any known number of revolutions per minute and amount of feed, within the range of the chart. The right-hand side of the feed scale, shown on the chart is graduated to 0.0025 inch with a range of from 0.01 to 0.04 inch so that practically any feed within these lines can be closely approximated. If desired, special feeds can be



Logarithmic Chart for Use in determining Turning Time

graduated on the left-hand side of the scale, as in the chart shown, and feeds being those for the Hendey lathe as given on the chart in the previously published article.

The chart is used in the regular manner, and is probably generally understood. After determining the proper feed for the class of work at hand and the lathe speed in revolutions per minute, a straightedge, laid so as to intersect these two graduated points on their respective scales, will cut the time scale as shown by the dotted line on the chart. The time obtained is that required for turning one inch of length, and as in the case of the curved-line chart, must be multiplied by the length of the piece to be turned in order to obtain the total time. The case illustrated on the chart shows that 1½ minutes is the approximate time required to turn one inch of metal, using a feed 0.0125 inch and a speed of 50 revolutions per minute. A chart of this nature may be used to determine the output of power presses in gross per day at varying press efficiency; and to ascertain the amount of stock required for screw machines to establish press operators' rates, etc. The writer believes that this type of chart is preferable to a curved-line chart on account of the readiness with which it can be read.

Hand Screw Machine Practice

Second Article Describing Tooling Equipments Used by the Warner & Swasey Co., Cleveland, Ohio, in Machining Castings and Bar Stock Parts on Hand Screw Machines

IN the first article dealing with various examples of hand screw machine practice, published in the March number of MACHINERY, a description was given of the tooling equipments used in machining various castings and bar stock parts, together with a detailed account of the sequence of the various steps in each operation or chucking. In the present article a description will be presented of the methods and tools employed in machining an aluminum bowl lined with ebonite, a cast-iron clutch cone, and a stud produced from bar stock, Warner & Swasey machines being used in all of the operations.

Tooling Equipments Used in Machining an Ebonite-lined Aluminum Casting

The bowl illustrated in Fig. 2 is a 99 per cent aluminum casting which has an ebonite lining. This part is finished all over in three chuckings on a No. 16 geared friction-head turret lathe. The aluminum casting is first finished all over in two chuckings, after which it is lined with ebonite as indicated in the illustration. A third chucking is then required to finish the various ebonite surfaces. The total time necessary for the three chuckings is only 12 minutes, which includes the time consumed in placing the work in the chucks, and removing it from the machines. Fig. 1 shows a machine provided with the tooling equipment used in the first chucking, there being a number of machined castings lying on the stand at the left of the machine. Fig. 3 shows a lay-out of the equipment with which this machine is provided. The sequence of the various steps in this chucking is as follows: (1) The bowl is placed in a three-jaw chuck that grips the work along surface *A*. (2) Surface *B* is faced and surface *C* is formed by the forming cutter *T* which is mounted on the rear of the cross-slide. (3) Surface *E* is formed by the circular forming cutter *U* which is held in the slide-tool mounted in Face 1 of the turret. After this cut has been taken the tool-holder and tools on this slide-tool are moved radially toward the center of the machine by means of the sliding arrangement and a rough cut is taken in hole *D* by the boring cutter *V* which is also mounted on the slide-tool. (4) Hole *D* is rough-bored by the four-fluted or "core" drill mounted in the box-tool in Face 2 of the turret, and a portion of surface *F* is faced by two cutters which are also held in this box-tool. (5) The remainder of surface *F* is finished and the circular groove *G* is formed by several cutters held in the box-tool mounted in Face 3 of the turret. (6) Groove *G* is dovetailed by the cutter mounted in Face 4 of the turret. (7) Surface *H* is bored by the boring cutter mounted in Face 5 of the turret. When this step is performed, the turret lock-bolt is withdrawn so that the boring cutter can be guided by a guiding block in contact

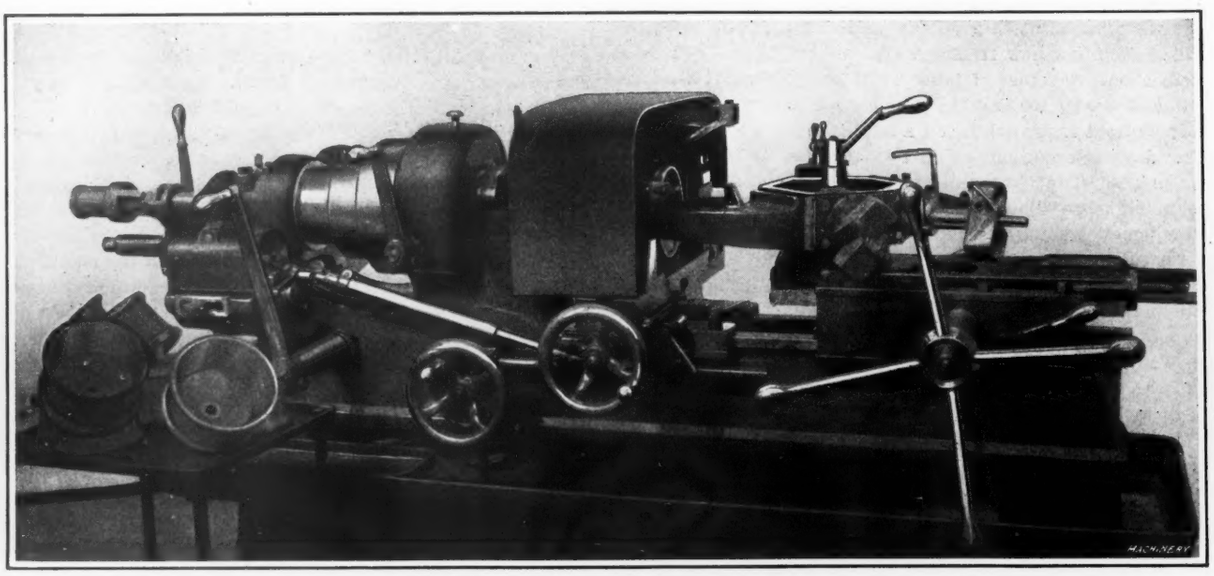


Fig. 1. Machine equipped for First Chucking on Aluminum Casting

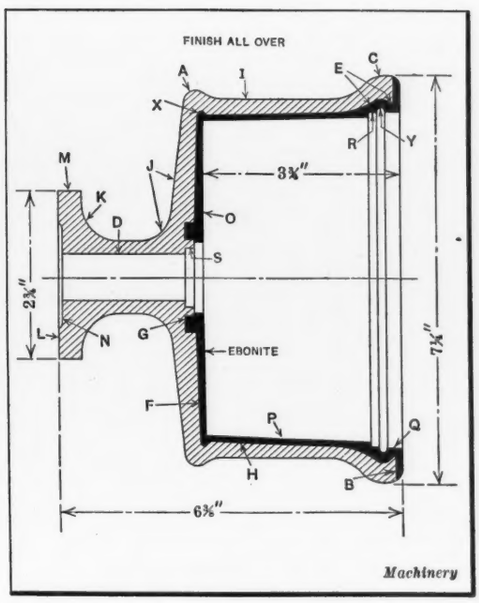


Fig. 2. Ebonite-lined Aluminum Bowl

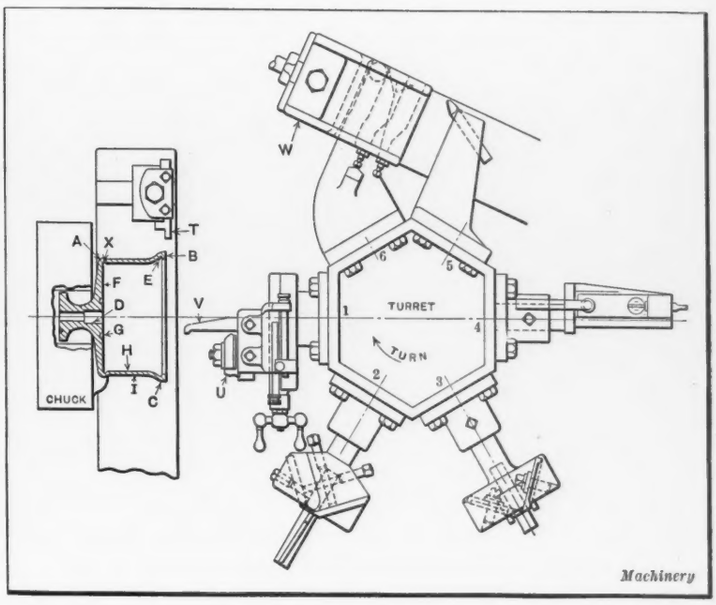


Fig. 3. Lay-out of Tooling Equipment used on Machine shown in Fig. 1

with a surface on bracket *W* that corresponds with the contour of the surface being machined by this tool. When the cutter has entirely machined surface *H*, groove *X* is produced by means of the same cutter being fed into the metal through the use of the cross-slide. Bracket *W* is really mounted on the front of the cross-slide, but is shown in the position indicated to illustrate its relative position with reference to the tool mounted in Face 6 of the turret, the bracket also being used in connection with this tool. (8) Surface *I* is turned by the cutter mounted in Face 6 of the turret. In this step the turret lock-bolt is also withdrawn and the cutter is guided along surface *I* by means of bracket *W* in the manner previously mentioned. (9) The work is removed from the chuck.

The tooling equipment used in the second chucking is illustrated in Fig. 4. This operation consists of finishing the remaining surfaces of the aluminum casting, the various steps of the series being taken in the following succession: (1) The work is mounted on a special draw-back type of chuck. (2) Surface *J* is faced and formed by cutter *a* which is mounted on a slide-tool on the rear of the cross-slide. The tool is guided by a block in contact with the slanting surface of guide *b* which is bolted to the side of the cross-slide saddle. (3) Surface *K* is formed by cutter *C;* surface *L* is faced by cutter *d;* and surface *A* is formed by the circular forming cutter *e;* all of these cutters are mounted on a tool-block on the front of the cross-slide. (4) Hole *D* is finish-bored by the boring cutter held in the adjustable boring-tool holder mounted in Face 1 of the turret. (5) Hole *D* is reamed by the reamer mounted in the holder in Face 2 of the turret. (6) Surface *M* is turned by cutter *f*, and surface *N* is counterbored by counterbore *g*, these tools being held in the box-tool mounted in Face 3 of the turret. (7) The work is removed from the chuck.

After the work is removed from the machine at the end of the second chucking, it is ready to be lined with ebonite as shown in Fig. 2. At the completion of this process, the work is subjected to a final operation, which consists of machining the several ebonite surfaces and counterboring surface *S*. A lay-out of the tooling equipment used in this chucking is illustrated in Fig. 5. The various steps in this chucking are taken in the following procedure: (1) The work is placed in a three-jaw chuck that secures the bowl on the machine by gripping it along the previously finished surface *A*. (2) Surface *P* is bored and surface *O* is faced by the cutter held in the holder in Face 1 of the turret. The turret lock-bolt is withdrawn for the performance of this step, the cutter being guided along surface *P* by means of a guide block in contact with a guiding surface on bracket *W* which is mounted on the front of the cross-slide. After surface *P* has been entirely machined, the same cutter is faced across surface *O* by means of the cross-slide. (3) Surfaces *Q* and *R* are bored by cutters *h* and *i*, respectively, and surface *S* is counterbored by counterbore *j*, these tools being held in the box-tool in Face 2 of the turret. (4) Groove *Y* is formed by the circular forming cutter *k* which is mounted in the slide-tool held in Face 3 of the turret. (5) The bowl, which is now completely finished, is removed from the machine.

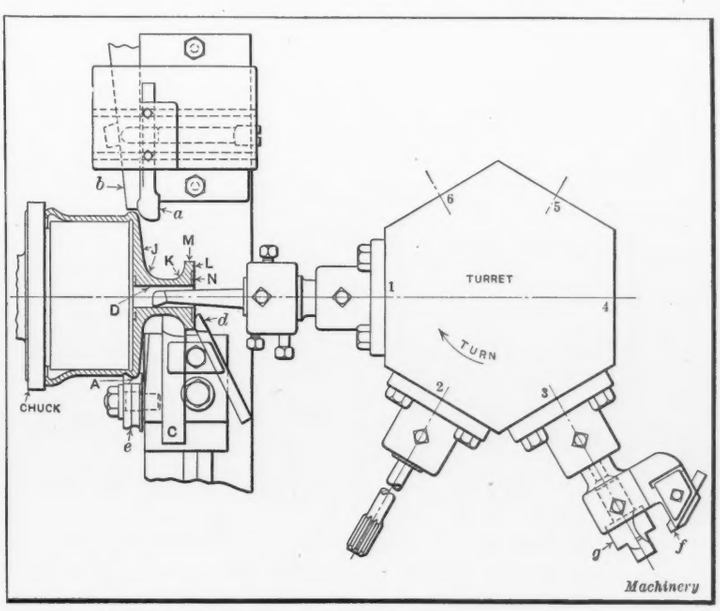


Fig. 4. Tooling Equipment required in the Second Chucking on Aluminum Bowl

Equipment Employed in Finishing a Clutch Cone

The cast-iron clutch cone illustrated in Fig. 6 is machined as indicated by the heavy lines in one chucking on a No. 4 universal turret screw machine. This operation requires 10 minutes. A lay-out of the tooling equipment provided on the machine used for this job is shown in Fig. 7. The successive steps in this operation are: (1)

The work is placed on a three-jaw chuck on which it is held by means of the jaws being expanded and exerting pressure on the inside of the cored opening. (2) Surface *A* is rough-turned by cutter *J*, and surfaces *E*, *F*, *G*, and *C* are rough-faced by cutter *K*, these cutters being mounted in the square turret. At the same time as these cuts are being taken surface *B* is rough-turned by cutter *N* which is held in an angle cutter-holder; surface *C* is finish-faced by cutter *O* mounted in a straight cutter-holder; hole *D* is rough-bored by the cutter mounted in boring-bar *P;* and surface *E* is finish-faced by cutter *Q* which is held in a facing head. The boring-bar and various tool-holders used for mounting these cutters are held in the adjustable turning head mounted in Face 1 of the turret. (3) Surface *B* is finish-turned by cutter O_1, and hole *D* is finish-bored by the cutter mounted in boring-bar P_1, the boring-bar and cutter being held in the single turning head mounted in Face 3 of the turret. At the same time, surface *A* is finish-turned by cutter *R* which is mounted on the taper attachment, and surface *G* is finish-turned by cutter *L* which is held in the square turret. (4) Hole *D* is reamed by the reamer mounted in Face 5 of the turret. (5) The threads on surface *B* are cut by cutter *M* which is mounted in the square turret and which is used in conjunction with a thread chasing attachment. (6) The finished casting is removed from the chuck. A machine equipped with the tools used in this chucking is shown in Fig. 8. This illustration shows the work ready to be removed from the machine. A close-up view of the same machine is illustrated in Fig. 9 and clearly shows the appearance of the work at the completion of the operation.

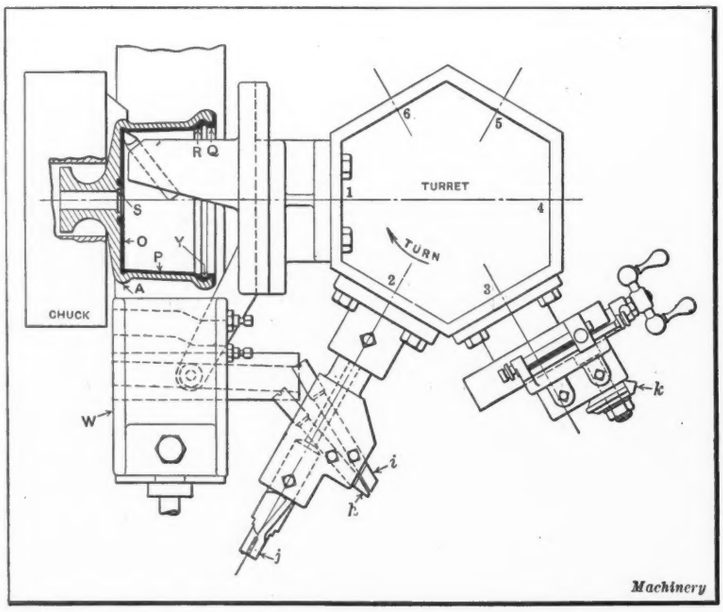


Fig. 5. Equipment employed in machining Ebonite Surfaces of Bowl

Producing Special Studs from Bar Stock

Fig. 10 shows a special stud which is produced from 1⅛-inch round bar steel. This part is machined in 7 minutes on a No. 4 universal turret screw machine. This includes the time required to feed the stock to the stop and to cut the finished stud from the bar. A lay-out of the tooling equipment required in manufacturing this part is shown in Fig. 11. The various steps in this operation are taken as follows: (1) The stock is fed to the combination stop and starting drill which is held in Face 1 of the turret, after which a spot is drilled in end *G* by means of this drill. (2) Surfaces *A* and *B* are turned by the tools mounted in the multiple-cutter turner in Face 2 of the turret, while surface *C* is turned by cutter *J* which is held in the square turret. (3) Hole *E* is drilled by the drill held in the holder mounted in Face 3 of the turret, and surface *D* is turned by cutter *J*. (4) Chamfer *F* is produced by the center drilling tool mounted in Face 4 of the turret. (5) Grooves *H* and *I*, Fig. 10, are turned by the cutter mounted in fixture *K* which is held in the square turret, Fig. 11. (6) End *G* is rounded by the pointing tool mounted in Face 5 of the turret. (7) Surface *A* is threaded by the die-head held in Face 6 of the turret. (8) Finally the finished stud is cut from the stock by cutter *L* which is mounted in the square turret.

The examples of hand screw machine practice described in the foregoing indicate clearly the importance of selecting the proper sequence of operations in order to obtain the most economical methods of manufacture.

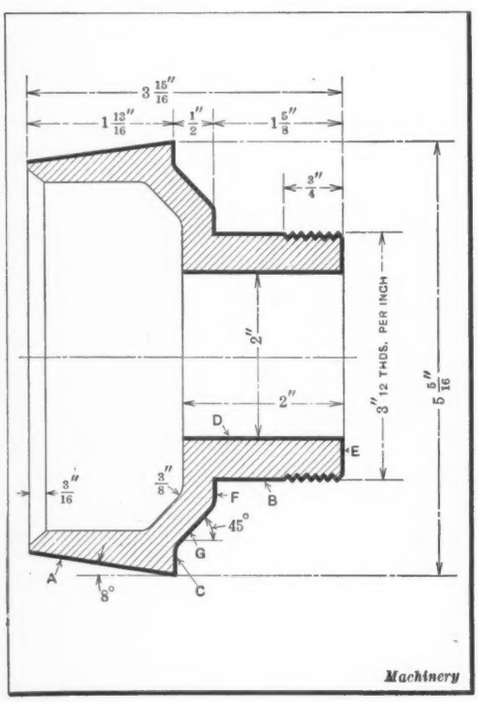


Fig. 6. Drawing of Cast-iron Clutch Cone

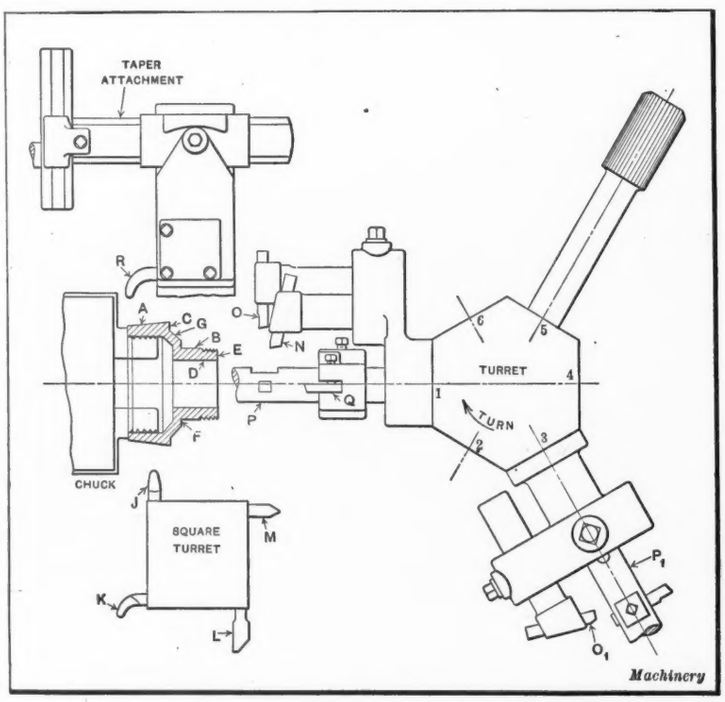


Fig. 7. Tool Lay-out used in finishing Clutch Cone shown in Fig. 6

THE DISPOSAL OF OLD COMPRESSED-GAS CYLINDERS

Some time ago a rather unusual incident occurred in a manufacturing plant says *The Traveler's Standard*, showing the necessity of handling with great care cylinders or tanks used as containers for compressed gases. In the plant referred to, large quantities of steel and iron scrap of the most miscellaneous character are melted in an open-hearth furnace and the metal thus obtained forms the basis for the manufactured products of the plant. At one time a compressed-gas cylinder was received with other scrap, and upon being thrown into the furnace it exploded and blew the entire top off the furnace. This experience was remembered, and when a similar gas cylinder was received on another occasion, it was taken off the charging buggy and thrown on the charging floor. Several hours later one of the employes, observing that the valve on the cylinder was still in place, secured a wrench and opened the valve. The cylinder had been filled with chlorine, and enough of the gas was released to cause serious discomfort to three men, and to make them unfit for work for several days. Not long after this occurrence still another gas cylinder was found in the scrap, and examination revealed the fact that it contained something like 25 pounds of anhydrous ammonia. This also might have caused trouble if it had been put into the furnace or left lying about the plant. As a result of these experiences, an order was issued to the effect that all cylinders thereafter received should be taken to the "skull-cracker" and broken up, before charging them into the furnace. There are at least two lessons to be learned from these experiences: (1) Compressed-gas cylinders should not be exposed to high temperatures unless it is known, positively, that they are *entirely* empty (and if the valve is still in place and closed, and there are no easily seen openings in a tank, it is safer to assume that it is *not* entirely empty); (2) all possible precautions should be used when opening gas cylinders, even if they are supposed to be empty—do it out-of-doors, be sure there are no fires or open flames anywhere in the vicinity, and have the work done by some person who understands the dangerous properties of gases. A warning of particular importance to the users of compressed gases is this: Be sure each cylinder is empty before discarding it, and if any gas remains in the cylinder, see that the cylinder is put in a safe place and marked in some way so that it cannot possibly be thrown on the scrap pile through error. Instead of scrapping a gas cylinder, return it to the gas manufacturer. If it is in good repair it has a money value and can be re-filled and sent out again; and if it is no longer serviceable, the manufacturer will know how to dispose of it safely. If a cylinder is received in a leaky condition, leave it out in the open air and protect it so that inquisitive persons cannot be harmed by the escaping gas; and if the gas remaining in the cylinder cannot be used safely, notify the gas manufacturer and ask for instructions regarding it.

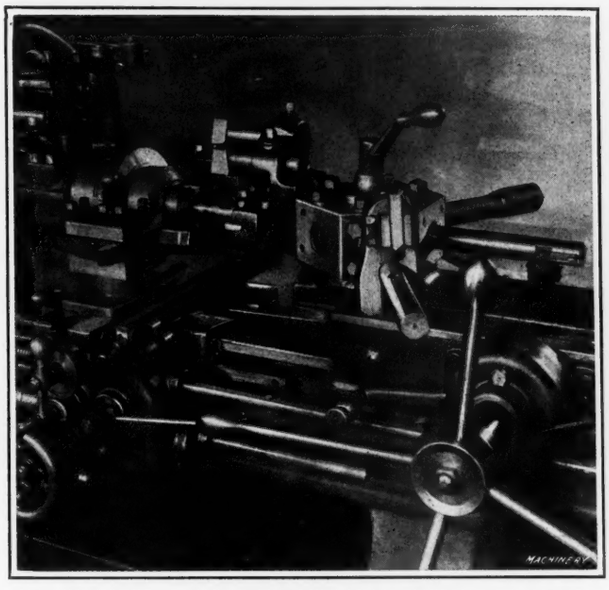


Fig. 8. Machine provided with Equipment required in machining Clutch Cone

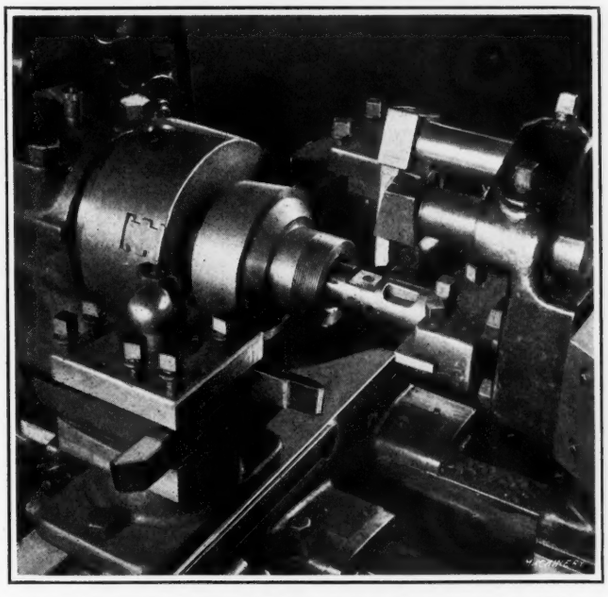


Fig. 9. Close-up View of Machine showing Work at the Completion of the Operation

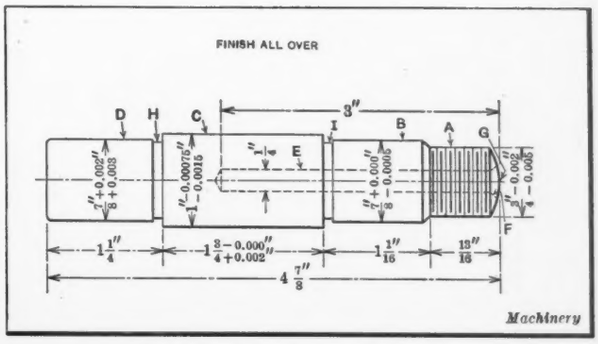


Fig. 10. Stud produced from Bar Stock on Hand Screw Machine

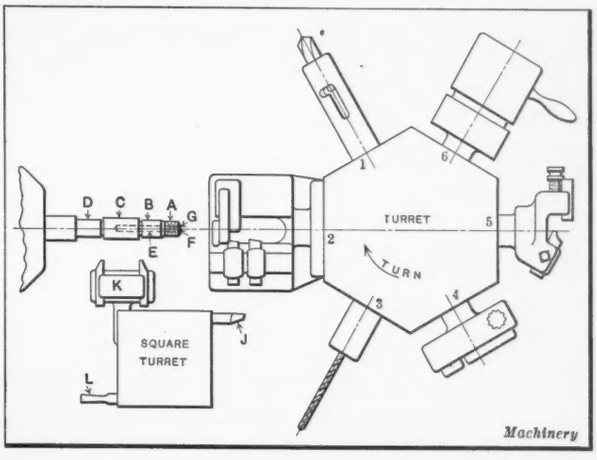


Fig. 11. Lay-out of Tools used in manufacturing Stud illustrated in Fig. 10

* * *

The Association of Chinese and American Engineers was recently formed in Peking, China. Forty engineers joined the association at its first meeting. More than one-half of the important engineering positions in China to-day are held by Chinese educated in America.

View in Willys-Overland Forge Shop

Successful Substitute for Apprenticeship

ONE of the troublesome problems which confronts the management of present-day metal-working plants is how to obtain the necessary number of capable all-around mechanics. Frequent reference is made in the technical press to the demand for such thoroughly trained men; and one hears the subject discussed in most gatherings of manufacturers of metal products. Years ago, this question was of little importance, because in order to earn an adequate wage in the machine shop, a boy had to serve a term of apprenticeship, during the course of which he received a thorough grounding in the basic principles of mechanics. But the departmental method of factory administration now in vogue has changed this situation. A boy is able to enter the employ of a manufacturing firm and receive sufficient training in about two weeks to enable him to operate a given type of machine engaged on a single operation; and in the performance of this repetition task, he will soon acquire sufficient dexterity to earn a fair wage, without serving four years' apprenticeship at a nominal rate of pay.

This tendency for boys to avoid apprenticeship has been found unsatisfactory for two reasons: From the employe's viewpoint it is undesirable, because while he is able to quickly reach a point where he can earn a fairly good wage as a machine operator, there is little possibility of making much further progress, owing to a lack of training in the fundamental principles of mechanics. And from the employer's point of view, the result is equally unsatisfactory because it fails to develop men possessing sufficient mechanical knowledge to be able to enter upon more responsible work; also, men trained as machine operators never can be expected to take the same interest in their work as those having a knowledge of the reasons why certain standards of workmanship must be maintained. A further disadvantage of the ordinary machine operator is that he has not the same ambition for promotion as a trained mechanic.

A Successful System of Labor Training

With a view of overcoming these undesirable characteristics of employes who are merely trained for the performance of repetition work, and also to provide a source of semi-skilled labor, the Willys-Overland Co., Toledo, Ohio, has recently established a training shop which is operated according to a carefully developed system of labor training. In common with the practice followed in the vestibule shops of wartime, this system keeps the "improvers," as the men taking a course of training are called, engaged upon regular lines of production work. This not only gives them a knowledge of the exact class of machine on which they will be employed upon entering the regular manufacturing department of the plant, but it also avoids the wasting of material on exercise work, and enables the training shop to be self-supporting, through the value of the product which it turns out. In this connection, it is important to note that the average amount of work spoiled in this training shop does not exceed 1.4 per cent, which includes all pieces that failed to pass the usual process of inspection. This is substantially lower than the average rate of spoilage in regular manufacturing departments. The training shop is equipped with all standard types of machine tools which are used in the manufacture of parts of the Willys-Overland car, and the "improvers" are able to obtain instruction in operating any of the machines in which they are interested.

How the System is Applied

Having made a brief general statement as to the manner of conducting this training shop, a more detailed description of its functions can now be presented. It has already been explained that the purpose is not only to afford a means of training new employes in the performance of the work on which they will be engaged in the plant, but also to afford a means of "up-grading" the men who are already employed in the factory. Regardless of whether the improver who enters the training shop is just entering the employ of the Willys-Overland Co. or has been on its payroll for a considerable period of time, he will be paid during his period of instruction in the performance of a new class of work at a rate 10 per cent lower than the regular price paid for the same job in a manufacturing department of the factory. By reducing the rate paid to men in course of training to 90 per cent of the regular rate for the same job, sufficient compensation is made for the lower productive capacity of such men so that the value of the product which they turn out will be sufficient to pay the expense of maintaining the training shop, exclusive of overhead charges.

Another highly important function of the training shop is to afford a means of definitely estimating the amount of skill possessed by men who represent themselves as capable operators of a given type of machine, at the time when they first come to the employment office for an interview. Every experienced shop man knows of the serious delays and spoil-

age of material which are frequently caused by men entering a production department on their own representation that they have received training in a given line of work, when they are utterly incapable of handling such work in an efficient manner. By sending all employes through the training shop, regardless of the claims which they make concerning their experience and ability, a reliable opinion may be obtained from the training shop foreman as to the degree of efficiency with which each man can handle the work on which he is to be employed in the plant. The most important consideration in this connection is that the work of all men can be carefully watched in the training shop to prevent the possibility of a lot of pieces being spoiled before the inefficiency of the operator is discovered. Naturally, experienced men who can demonstrate their ability are soon transferred from the training shop to a manufacturing department of the factory.

Fig. 1. Partial View of the Training Shop where Advanced Instruction is given in Automotive Machine Shop Work

Creating Incentive for Promotion

One of the great features of this system of labor training is that it serves the double purpose of affording a means for ambitious employes to obtain a thorough knowledge of their trade, while earning a rate of pay that enables them to keep up with American standards of living; and by so doing, solves the manufacturers' problem of securing an adequate supply of fully trained, or so-called "all-around" mechanics. For ordinary classes of machine work, it takes from a few hours to as much as two weeks to train an operator to a point where he is able to attain the rate of production that is required in a manufacturing department of the plant. But after he is sent out from the training shop, it does not necessarily mean that his experience with that institution has come to an end. The future is optional with him, and if he so desires he can come back for repeated courses of training in a number of different classes of machine work until he has finally gained a thorough knowledge of his trade.

It is this feature of this system of training which was largely responsible for instituting the 10 per cent reduction in wages paid to "improvers" employed in the training shop. The amount of work done by such men during their short period of training is naturally less than that of experienced operators, so that it is eminently fair for them to be paid a lower wage; but the main object in making the reduction is to deter all employes from seeking an opportunity for additional training in the shop, except those who are possessed of an earnest desire to succeed and are willing to pay for the gratification of this desire by accepting a slightly lower wage during the time they are securing the desired training. Those who are considering the merits of this system with a view of introducing it in their own plants, are likely to ask the question, "How is one to prevent an operator of one of the simplest types of machine tools, who has had no other mechanical experience, from attempting to secure training as an operator of one of the more complicated types of machines, where he will earn something approaching the maximum machinists' rate of pay?"

How the Development of All-around Mechanics is Attained

In other words, this question resolves itself into, "How is the management of a plant in which this system of training is employed, going to arrange matters so that the men will obtain training in all departments of a machinist's trade?" The answer to both questions is, "Where applicants are being considered for training in any class of work, the successful candidates will be those who are at present employed on a class of work most nearly allied to the one in which they desire to be trained." This makes it necessary for the man at the bottom of the ladder to approach his goal rung by rung, in order to gratify his ambition to reach the top, both as regards pay and responsibility.

According to the usual system of apprenticeship, a boy is required to sign an indenture contract for a period of four years, at a purely nominal rate of pay; and an actual analysis of his four years' work will show that in many cases a large percentage of the time has been spent in the performance of classes of work that were profitable to the employer, but where the employe obtained very little experience of value to him. If this contention is accurate, it is fair to assume that a man gaining his experience by this system can take a number of rapid courses in the training shop and alternate this with practical work in manufacturing departments of the factory, with the result that he will not only secure as comprehensive a training as that given to the apprentice boy, but that he will also earn a very satisfactory average rate of wages during the entire period.

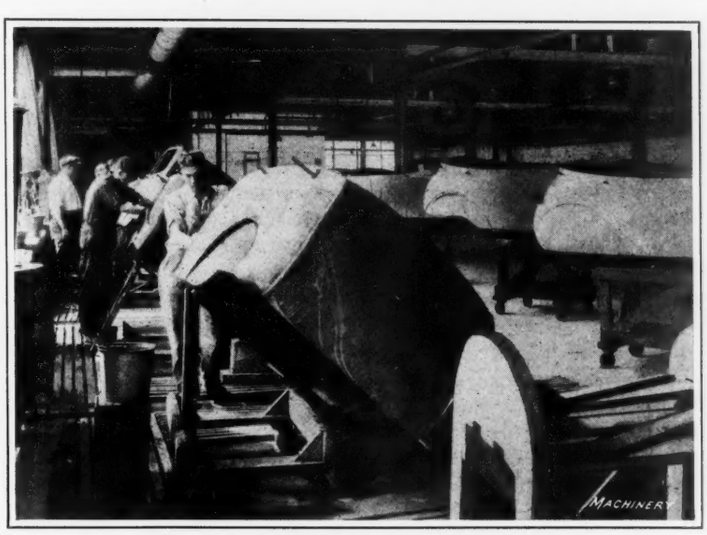


Fig. 2. Instruction is given in painting Motor Car Bodies, an Operation which requires Skill and Judgment

A Constantly Increased Earning Capacity for Ambitious Men

It will be evident to one who gives this plan a brief consideration, that the rate of pay earned by a man who repeatedly returns to the training shop for knowledge of more advanced lines of work, is constantly being raised. For instance, a man who is receiving initial training in a job

paying 40 cents an hour, earns 36 cents an hour during his training. After he has worked on this job in the manufacturing department for a sufficient period to gain an adequate knowledge of the work, he may return to the training shop to qualify for a job paying 45 cents an hour. During the period of training, he will earn 40½ cents an hour, which is in excess of the rate he was earning in a manufacturing department; and after being trained, he goes back to the factory at the 45 cent rate. By constantly repeating this practice, he not only gains a wide mechanical experience, but is also able to constantly increase his earning power. This financial incentive is sufficient to act as a spur for those men who would not be tempted to make these repeated changes in order to qualify for advancement into a responsible position.

At specified intervals, lectures are delivered to groups of foremen and other factory executives. The purpose of these lectures is to impress upon foremen the value of improving the quality of labor employed in their respective departments.

Incidentally, the quality of service obtained from the foremen is also improved because these lectures impress upon them the fact that their departments are going to be filled with trained men who will be qualified to assume the duties of a foreman. Last, but far from least, the point is emphasized that with a training shop for the development of thoroughly experienced mechanics, any important factory executive positions which become vacant can be filled with men taken from the company's payroll, instead of resorting to the practice of seeking them elsewhere. In any plant, there will always be a lot of men who are content to work from day to day and spend their wages as received; but there will also be a certain percentage of the exceptional men who are anxious to succeed; and by emphasizing the possibility of promotion, which is afforded by this system of training, the ambition of such desirable employes will be stimulated instead of allowing them to become discouraged by the numerous obstacles which the regular departmental method of factory management throws in the way of advancement for the rank and file of machine operators.

* * *

CORRECT STATEMENT OF AVERAGES

In an article appearing in a recent number of *Mechanical Engineering*, the author, Henry Hess, points out the difference between the usual method of expressing averages and the correct method. The dictionary definition of average is as follows: "Average: A sum or quantity intermediate to a number of different sums or quantities, obtained by adding them together and dividing the result by the number of quantities added; an arithmetical mean. Thus, if four persons lose, respectively, $10, $20, $30 and $40, the average loss of the four is $25."

The dictionary definition is correct, but incomplete; consequently the majority of people and engineers who deal with averages fail to realize how absolutely misleading the definition is. For example:

(1) The average of $2 + 3 + 4 = 3$
(2) The average of $1 + 3 + 5 = 3$
(3) The average of $3 + 3 + 3 = 3$
(4) The average of $2 + 2 + 5 = 3$

In these four instances, the average does not express the amount that the *stated* average differs from the original value. This difference should be expressed when stating averages, thus:

(1) 3, plus or minus 1;
(2) 3, plus or minus 2;
(3) 3, plus or minus 0;
(4) 3, plus 2 or minus 1.

When the averages are expressed as shown above, it is at once clear that in the first case the terminal values of the series are 2 and 4; that in the second case they are 1 and 5; in the third case 3 and 3; and in the fourth case 2 and 5. It is a matter of decided importance to know whether the maximum and the minimum values of a series differ much or little from each other. The importance of this statement is further emphasized by Mr. Hess when he cites an incident from his own personal experience: Occasion arose casting doubt on the uniformity of the strength of balls of a well-known and highly regarded make. On voicing that doubt to the manufacturer the assurance was given that carefully conducted tests on a considerable quantity of balls showed marked uniformity within a relatively few points. A request for the tabulated results of these tests brought forth the complete data, which showed that the claim was made in perfectly good faith but was nevertheless in error, because the averages took into account the *ordinary* average only, the plus and minus variations not having been considered. The tabulation, including the breaking loads of the three series of balls of equal diameter, is shown below.

	62,500	76,000	93,500
	68,000	84,500	63,000
	72,000	86,000	74,000
	94,000	91,000	69,000
	83,000	75,500	71,500
	379,500	413,000	371,000
Average	75,900	82,600	74,200

Considering only the ordinary average, these values do not show a very serious difference. If these averages had been expressed correctly, a clue would have been furnished from which the seriousness of the amount of divergency from the stated average would have been apparent. Following is the correct method of expressing the true average for the breaking loads of the three series of balls:

$$75{,}900 \begin{matrix} - 13{,}400 \\ + 18{,}100 \end{matrix} \qquad 82{,}600 \begin{matrix} - 7400 \\ + 8400 \end{matrix} \qquad 74{,}200 \begin{matrix} - 11{,}200 \\ + 19{,}300 \end{matrix}$$

The ordinary average, 75,900, gave no indication as to whether this was an average of 75,901 and 75,899, with a difference of only one point plus or minus, or whether the difference was great, as the plus and minus values clearly showed to be the actual case.

The misleading use of the term average is so general that it is even found in such standard works as engineering handbooks. For instance, one authority gives the compression in pounds per square inch of granite as averaging 15,000 pounds, and for four different varieties gives 12,000, 15,000, 16,000, and 15,000 pounds. The true average of these four varieties is 14,500, — 2500 + 1500. If the strength of all granites lies between the limits of these four varieties, the complete average stated gives safe data. In another case the average for slate is given at 10,000 pounds, but no varieties are quoted; yet it is certain that all slates are not of the same strength. The completion of the average by the use of a minus and a plus limitation would give the necessary information.

It is certain that some steel castings have higher elastic limits than 40,000 pounds per square inch; this value is quoted by one authority as an average, but the range is not given. A complete statement of the average would substitute definite information for guesswork.

On the basis of the above comparison of the statement of averages, a more complete definition than that found in the dictionary would be: "Average is that quantity intermediate to a number of different quantities obtained by adding together these quantities, dividing the result by the number of quantities that were added, supplemented by a statement of the quantities by which the result differs from the largest and the smallest of the quantities. Thus, of four sums, 10, 20, 30 and 60, the average sum is $30 \begin{matrix} - 20 \\ + 30 \end{matrix}$."

* * *

In a paper read before the American Society of Mechanical Engineers, N. C. Harrison defines pulverized coal as coal that has been reduced to such fine particles that at least 95 per cent will pass through a 100-mesh sieve, such a sieve having 10,000 openings to the square inch. The finer the coal is pulverized, the more efficiently it can be burned.

Furnaces Used in Heat-treating Steel

Comparison of Types of Furnaces Used in Carburizing, Hardening and Tempering

By S. P. ROCKWELL, Metallurgist, Weekes-Hoffman Co., Syracuse, N. Y.

IF the fuel is disregarded, there are really only three types of furnaces used in the heat-treating of steel—the under-fired, over-fired, and hearth- or heating-chamber-fired. The under-fired furnace is one in which the initial heat of combustion is generated below the hearth and then carried to the heating chamber through the hearth. (See *A*, Fig. 1). This type of furnace is, as a rule, best adapted for reheating, in which it is not desirable to have the products of combustion or the flames strike directly against the work. As the heated gases flow against the sides of the hearth, thus heating the edge up more than the remainder, it is better to have walls at the edges of the hearth as shown at *B*, especially if the hearth is of considerable width. The value of this construction lies in its simplicity and lightness, and most portable furnaces are built in this manner. Some modifications may be made in the flue arrangement of the combustion chamber, but these modifications in all cases tend to break up the products of the combustible gases and to distribute them evenly. In this way the gases entering into the heating chamber are of the right chemical proportion to give the best results to the work. Further, this distribution tends to keep the heating chamber at an even temperature, which depends on the distribution of the work and the method of handling it, including the door operation.

The temperature of the combustion chamber is usually in excess of the temperature of the heating chamber, especially when the furnace is being "rushed." For this reason the hearth breaks up, due to its supports warping and cracking, and allows the combustion gases to pass through and strike the work. As repairs are then necessary, furnaces of this type should be designed so that the hearth may be easily removed and the combustion flues will be readily accessible, without ripping open the outside walls or the entire front of the furnace. The best quality of heat-resisting brick should always be used in building the hearth and the combustion flues, and in portable furnaces of this type the flues are usually made of slabs from 2 to 4 inches thick. In non-portable types, where lightness is not a consideration, the combustion flues may be arched over and the floor slabs set on the arches as illustrated at *C*. This construction will require fewer repairs, but they will be more expensive. When the work undergoing treatment is heavy, such as heavy carburizing pots, a furnace of this construction is required. If the hearth plates are broken in this type of furnace, they can be easily replaced.

An over-fired furnace is one in which the combustion chamber is above the heating chamber arch, the combustion gases being carried to the heating chamber through perforations in this arch, and leaving the furnace at the bottom of the hearth, as shown at *D* in Fig. 1. This type of furnace is not commonly used, as the arch construction is expensive and delicate. The ill effects produced by high temperatures in the combustion chamber of the under-fired furnace are the same as those referred to in connection with the over-fired furnace. The principle of the over-fired furnace is wrong, because heated gas has a tendency to rise, and in this type of furnace, extra draft must be used to draw the heat down. For extremely high furnaces, this type can be used in conjunction with the under-fired type. Its construction is also suitable for furnaces requiring removable hearths which are mounted on wheels, where there is no possibility of using the under-fired type. Such a furnace is shown at *A* in Fig. 2.

In a hearth- or heating-chamber-fired furnace, the initial heat of combustion enters directly into the heating chamber, as indicated at *B*. This type of furnace is usually constructed to allow the gases to come into direct contact with the work, and on account of fuel impurities it is not desirable for the heat-treatment of finished products. In carburizing, however, the work is protected and excellent and economical results can be obtained if there are proper flue outlets. This type of furnace can also be used for annealing if the product later undergoes machining. The removable

type of hearth can also be installed in this furnace.

Methods of Handling Waste Gases

Furnaces may be designed for various classes of work, but they generally embody features of the standard types or a combination of them. The main difference in the design of furnaces is the method of handling the waste gases. When designing the flues, it is important to make sure that they do not let gases pass out that contain available heat which could be used for the work, and that they are smaller in area than the flues entering the heating chamber from the combustion chamber. This is so that a slight pressure may be kept on the gases in the heating chamber which will prevent cold air from entering the furnace when the doors are opened. It is often advisable to place a damper in these flues to check off the escaping gases and allow the pressure to be regulated at will.

It can be readily seen that the flue arrangements of the furnaces shown at *A*, *B*, and *C*, in Fig. 1, are poor from the standpoint of heat-saving, as the waste gases leave the furnace at the top, thus losing a great deal of available heat. The flues, however, may be closed by placing a brick over them, and if there is more than one flue in a furnace, the heat can be thrown toward the back or front of the furnace at will. The flue arrangements of the furnaces shown at *D*, Fig. 1 and at *B*, Fig. 2, are better, as the hot gases are brought back under the hearth and are thus partially utilized. If this arrangement is used in constructing such furnaces as shown at *A*, *B*, and *C* in Fig. 1, and the majority of the waste gases are removed from the heating chamber near the door or at the ends of the furnace and then led under and lengthwise across the hearth, the maximum benefits will be obtained. An ingenious method of handling these waste gases was developed in designing a furnace for annealing coiled wire. It was required that the furnace be large enough in diameter for the coils and at least 12 feet long. The wire had to be annealed bright, as no pickling was allowed. Fig. 3 shows the under-fired type of furnace built for the purpose.

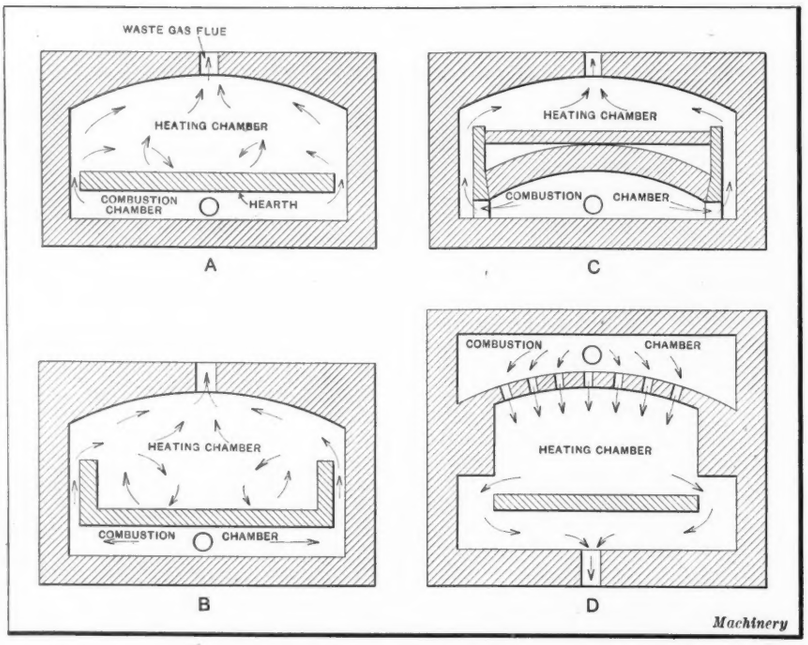


Fig. 1. Diagrammatical Sections showing Principles of Under- and Over-fired Furnaces

The wire is first placed in the cylindrical boiler plate tanks *A* and *B* which have a hole through the center of the bottoms and covers. Small hollow cylinders *C* and *D* are then placed in the center of the coils over the holes in the tanks, and charcoal is packed between the cylinders and the coils and around the outside of the coils. The tanks are next placed in the furnace, one on top of the other. Oil is used for fuel, and it enters the furnace at an angle so as to give a rotary effect to the gases. The small cylinders in the center of the wire pots act as return flues for the gases.

In the Smallwood type of furnace, the gases from the heating chamber pass out at the rear of the hearth and then up over the heating chamber arch and out at the front end of the furnace, at the top, as shown at *C* in Fig. 4. Although carefully planned, a furnace may not show an even temperature when loaded with work. To guard against this, it is always desirable to so design the furnace that the area of the flues entering into the heating chamber may be cut down by sliding bricks over them, as previously mentioned. This will allow any part of the furnace to be brought to a higher or lower temperature.

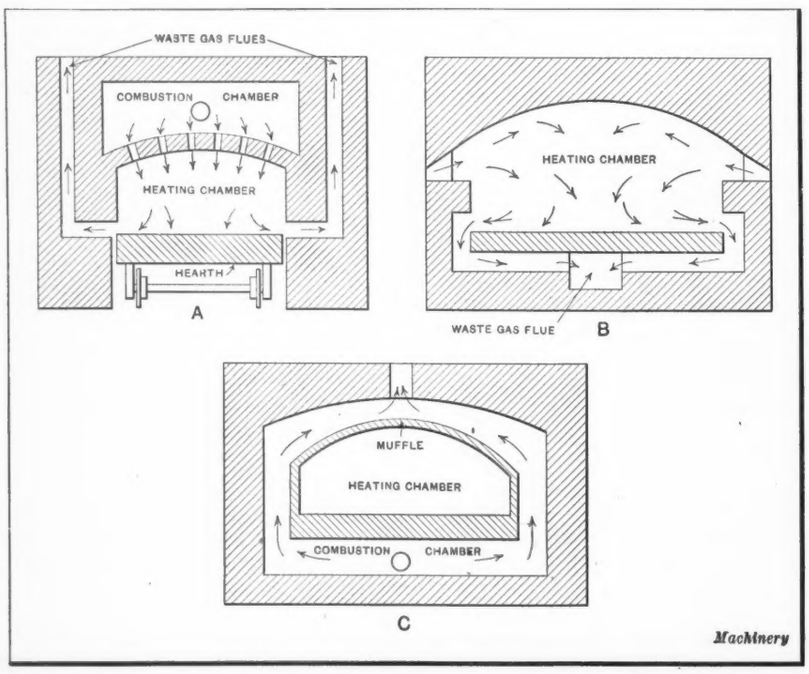


Fig. 2. Diagrammatical Sections showing Principles of Over-fired and Muffle Furnaces

Design of Combustion Chambers

The openings from the combustion chamber to the heating chamber should be so designed that a slight pressure can be applied to the gases in the combustion chamber. In this manner the temperature of the combustion chamber can be kept more even. This can be done by making the total area of these openings slightly less than the cross-section area of the combustion chamber. The usual combustion chamber lay-out for furnaces of the type shown at *A* and *B* in Fig. 1, is illustrated at *A* in Fig. 4. The walls of this type of chamber support the floor tiling. In furnaces using oil for fuel, each successive opening in the wall, from the front to the back of the chamber, is ½ inch smaller than its predecessor. This produces a friction on the hot gases entering the heating chamber furthest from the burner, and allows their free passage at the front, which evens up the effect of the flame-throwing force of the burner. If the furnace is particularly wide and

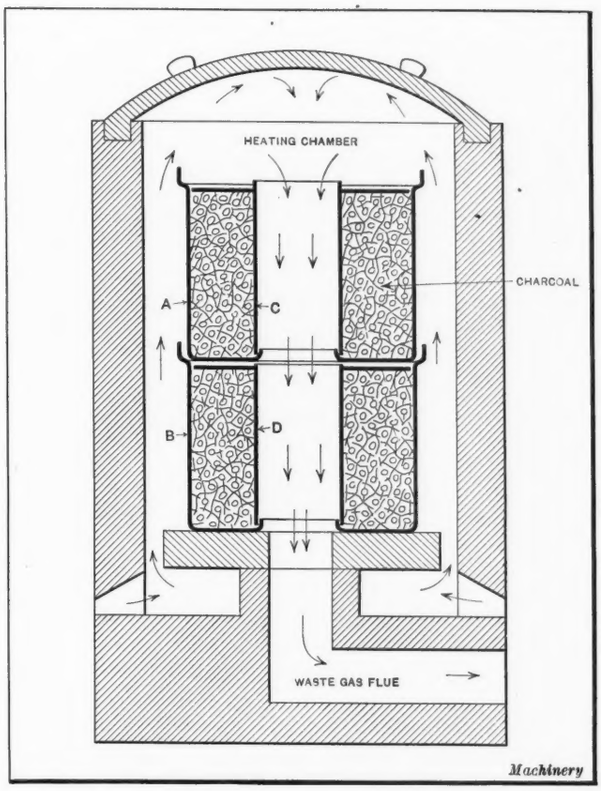


Fig. 3. Special Under-fired Furnace used for annealing Coiled Wire

oil or gas is used as fuel, another supporting wall is placed in the center, and combustion from the burners takes place on both sides of this wall and between the outside walls.

For small furnaces, 36 by 48 inches or less, some such arrangement as shown at *B* in Fig. 4 can be used. This method is particularly suitable for oil-burning tempering tank furnaces in which red heats are not used, but where incandescence of the brick in front of the burner is necessary to prevent the burner from going out. The height of the walls is governed by the size of the furnace and the maximum temperature. Large hearths, of course, require more fuel than small hearths and there should be space enough for the combustion of the gases. No combustion chamber should be less than 5 inches in height, and this height should be increased roughly 1½ inches for every additional 5 square feet of hearth space that is in excess of 5 square feet.

In the Smallwood type of furnace, a slightly different form of combustion chamber is used which is in reality, a modification of the construction shown at *A*, Fig. 4. It is claimed that this construction causes double combustion of the heating gases, that is, a primary or partial combustion at the place of heat generation—as partial burning of coal or firing of oil or gas—and a final combustion of the gases generated from the first combustion. The method of arranging the combustion flues is illustrated at *C*. This principle can be carried out on a small scale several times under the same hearth, but this depends on certain conditions obtaining, such as long narrow furnaces or many sources of heat. When the hearth is extra wide, there should be openings from the central flue through the hearth, as shown at *T* and *U*, which tend to carry to the extreme ends of the furnace, the heat needed.

Designing and Building Furnaces

The materials for building the furnaces should be selected according to the requirements. For combustion chambers which will receive high temperatures, the best heat-resisting brick should be used. Heating chamber slabs should not be made of too soft brick, as they will wear when work is dragged or rolled over them. Conservation of radiated heat is of great importance from the standpoints of economy and comfort and is best maintained with insulating materials, such as magnesia, asbestos, and various insulating bricks. The heading illustration shows a row of carburizing furnaces built double to reduce radiation losses. Cast-iron sides are valueless except for portable furnaces, bought ready built, and for large furnaces having large door-openings. In stationary types, a red brick exterior braced by channel irons held vertically by tie-rods is sufficient. Angle-irons set horizontally in the red brick at the "skew backs" for the arches will hold the arches in place. Fig. 5 shows a furnace constructed in this manner.

The size of the furnace should be governed entirely by the size and amount of the work. A great mistake is often made in using a furnace having a capacity for large and heavy work, for heat-treating a few pieces of small work. For this reason a number of small furnaces are more satisfactory than one large furnace because fuel costs may be cut down when the amount of work decreases; and furthermore, production is not entirely stopped when it is necessary to make repairs. On the other hand, too small furnaces should not be used, as they are apt to heat the work unevenly, which happens when gases strike the work directly. When determining the size of a furnace to be used for carburizing, the daily production necessary and the time required for performing it should be considered. For example, assume that it is desired to build a furnace having sufficient capacity for carburizing, at one time, 300 ring gears, 8 inches in diameter and 1 inch thick, each one of which requires eight hours to be carburized all over, only day work being desired. A pot about 12 inches outside diameter and 14 inches high is a good size to use. Six gears can be placed in a pot of this size if the pot thickness is ¾ inch, the legs 2 inches high, and ½ inch of carburizer is placed between each piece of work, and from 1¾ to 2 inches is placed on top of the work. If six gears are placed in one pot, the number of pots required would be $300 \div 6 = 50$. Each pot takes up one square foot of hearth space. If 500 pieces of work is the maximum production

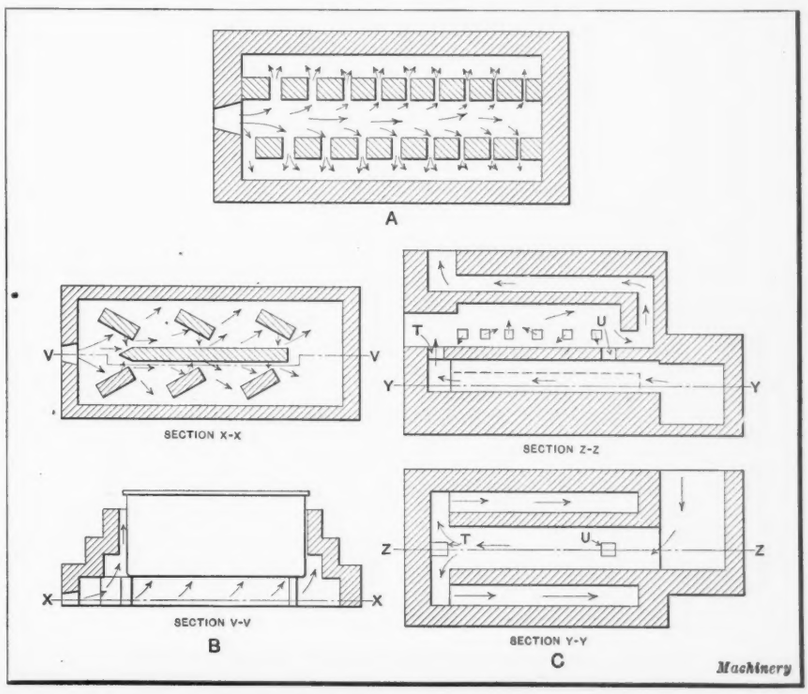


Fig. 4. Sections showing Various Combination Chamber Constructions

expected and the production may drop 33 1/3 per cent at certain times; three units are advisable. This means three 18-pot furnaces of about 18 square feet available hearth space or, say, 3 feet wide by 6 feet long. The combustion gases in furnaces of the types shown at *B* and *C*, Fig. 1 and *B*, Fig. 2, should enter the heating chamber at least 4 inches above the top of the pots, and the top of the arch should be at least five inches higher. The type of furnace shown at *A* in Fig. 1 should not be used. In furnaces of the type shown at *D*, Fig. 1 and *A*, Fig. 2, the distance from the top of the pots to the high point of the arch should be at least 5 inches.

Assuming that it is desired to harden the work once, it will be found that the time required for heating one gear will be about fifteen minutes. If they are quenched singly they should not be held more than ten minutes at the hardening temperature. Supposing that two pieces of work are quenched per minute in a Gleason hardening machine, ten pieces in a furnace at one time will be sufficient. Assume that the furnace is to be of sufficient length and width to take four rows of work, each containing five pieces, then in two rows, the gears can first be preheated, after which they can be moved to the other side of the furnace and their former place filled with ten new pieces of work. After the first ten have come to the proper temperature and are quenched, the routine is continued. There should be a space equal to the width of a gear between the two rows, or 8 inches; therefore the furnace should be about 4 feet wide by 5 feet long. A furnace of this size will have a capacity for heating forty gears per hour, so that if there are nine actual hardening hours in a ten-hour day, this means an output of 360 pieces per day, and thus one furnace will be sufficient. The height of the heating chamber can be equal to 1 1/3 times the height of the combustion chamber, but for convenient operation this height should not be less than 12 inches. The flue opening from the combustion chamber should be at least 4 inches above the work. The door openings may be made as small as convenient handling of the work will permit or about 4 feet by 8 inches.

As a general thing, it is more economical for a firm to build its own furnaces, as from 20 to 50 per cent can be saved, provided the furnace design is adapted to the work and is of a type which is known to give good results for that or similar work. Slight changes in these standard designs are permissible to meet individual shop conditions. The cost of having furnaces installed by outsiders is often excessive, as the builders must figure on selling costs, patents, superintendence, overhead expenses, and profit. Furnaces are often erected in banks to conserve floor space, heat and furnace walls. Large oil-fired carburizing furnaces are erected with two or four chambers as shown at *A* in Fig. 6, while hardening furnaces are erected in double or single banks as shown at *B*.

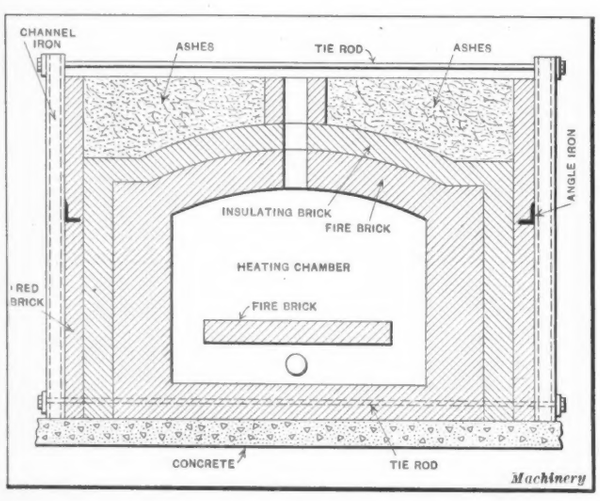


Fig. 5. Typical Construction of Stationary Under-fired Furnace

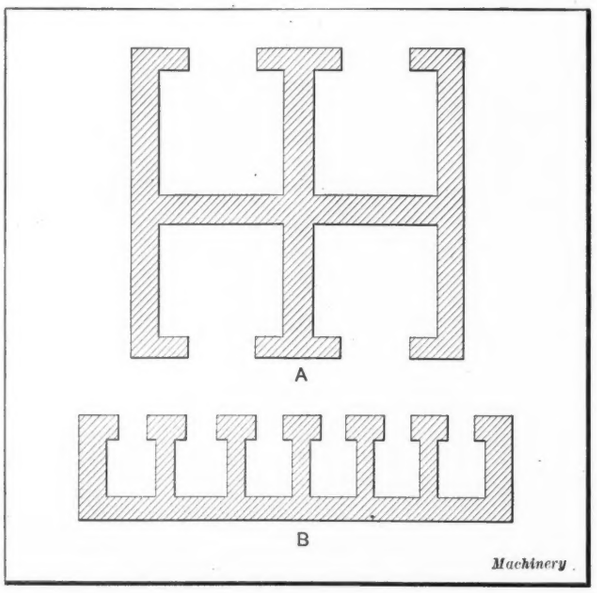


Fig. 6. (A) Method of erecting Large Oil-fired Carburizing Furnaces. (B) Bank of Small Hardening Furnaces

Automatic and Rotary Hardening Furnaces

Automatic furnaces or furnaces which are equipped with machinery for carrying the work through them, should be carefully considered before their installation, as they are often unsatisfactory. This is because proper heating is frequently overlooked in order to obtain a good mechanism, and as a result the metal is exposed to extreme temperatures resulting in warpage and burns. Complicated designs are apt to get out of order due to the number of parts, resulting in expensive repairs and long idleness.

The rotary hardening furnace has proved successful on certain classes of work such as set-screws, washers, nuts, pins, etc., but a number of large concerns who tried to use it on high-class ball bearings experienced trouble because every ball passing through the machine did not travel at the same rate of speed. The consequence was that some balls were not heated through while others were heated too long.

Muffle Furnaces

The principle of muffle furnaces is to improve the steel by separating the heated work from the combustion gases. There is no doubt that this is advantageous under the usual conditions of firing a furnace. However, with a properly designed furnace and proper burning of fuel, the combustion gases may be made practically harmless to the steel. The muffle type of furnace is apt to have more oxygen in contact with the metal than the open heating-chamber type as the result of sealing the work. To prevent oxidation, charcoal is often placed in the muffle to generate a protective gas that will burn up the oxygen and thus prevent the steel from scaling. The construction of a muffle furnace is similar to the three types mentioned, and if the furnace illustrated at *A* in Fig. 1 had a muffle placed on the hearth, as shown at *C* in Fig. 2, it would be considered a muffle furnace. Each pot in a carburizing furnace becomes an individual muffle furnace.

Surface Combustion and Lead Pot Furnaces

Surface combustion furnaces are only different from the types mentioned in that the gaseous fuel is broken into many little flames by impinging it on irregular surfaces or crushed material, such as firebrick. This causes the material to become incandescent and produces a more even throwing off of heat into the heating chamber. The principle is the same as having a multitude of small burners instead of one or a few large burners. As this method extracts the maximum heating value from the gas, its economy is great but the cost of hearth installation is high.

The lead pot furnace is often used in hardening carburized work, especially when the piece has been carburized all over and it is desired to have only part of the piece hardened. In this case only the part which is desired to be hardened is immersed in the lead and the part remaining outside of the lead, of course, does not reach the hardening temperature. Another advantage of the lead pot furnace is its ability to hold even temperatures. This is because the temperature of the mass of molten metal does not fluctuate readily. The lead pot furnace does not differ greatly from any of the three main types of furnaces, and can be likened to an inverted under-fired muffle furnace, the part containing the lead really being the muffle.

* * *

MILLING INTERMITTENT GEARS ON AN AUTOMATIC SCREW MACHINE

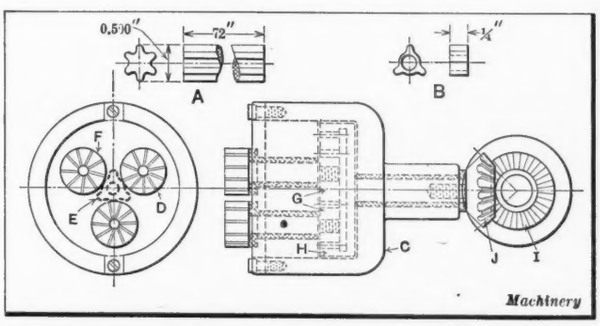
By JOHN J. McNIFF

The "skip" or intermittent gear shown at *B* in the accompanying illustration is made from brass pinion rod stock such as shown at *A*. This stock has six teeth, an outside diameter of 0.500 inch, and is furnished in bars 6 feet long. To produce gear *B* it is necessary to mill away every alternate tooth, drill and ream the central hole, and cut off the work. These operations are performed on a Brown & Sharpe automatic screw machine equipped with the special milling tool shown in the lower part of the illustration.

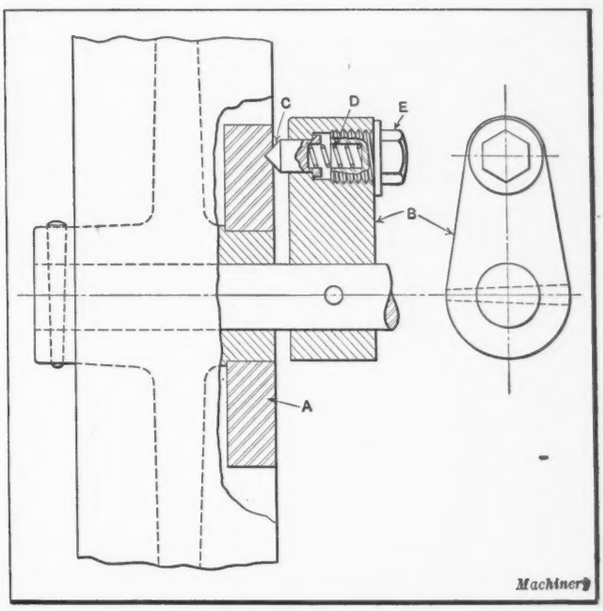
The most interesting features in connection with the production of these gears is the method of milling away the alternate teeth and the construction of the tool employed for the purpose. As shown, this tool consists of a body *C* carrying three end milling cutters *D*, *E*, and *F*. These cutters are mounted on arbors fitted with spur gears *G* which are driven by internal gear *H*. Gear *H* is driven through bevel gears *I* and *J*, gear I being keyed to a belt-driven spindle mounted in the post of the turret.

The cutters are fed forward by means of a lobe on the turret cam. The spindle of the machine is stopped and held stationary during the milling operation by a spindle brake provided for this purpose. The order or sequence of operations in machining the work is as follows: Center, drill, ream, stop spindle, mill, start spindle, cut off, feed stock forward, and repeat operations. When operating the machine at a spindle speed of 1800 revolutions per minute the actual cutting time and time spent indexing the tools into position may be determined from the following table:

Order of Operations	Number of Revolutions	Travel (Inch)	Feed per Rev. (Inch)
Revolve turret	22	....	....
Center	12	0.040	0.004
Revolve turret	22	....	....
Drill	32	0.320	0.010
Revolve turret	22	....	....
Ream	27	0.270	0.010
Revolve turret and stop spindle	24	....	....
Mill away teeth	56	0.280	0.005
Start spindle	22	....	....
Cut off	100	0.180	0.0018
Feed stock to stop	21	....	....
Total revolutions	360	....	....



Special Milling Tool employed on Automatic Screw Machine to produce Intermittent Gears



Slip Drive with Simple Spring-actuated Locking Detent

SLIP DRIVE FOR DRIVING PULLEY

By S. A. McDONALD

An arrangement which causes the driving pulley to be disengaged from the driving shaft when the machine becomes choked or when some part interferes with the proper functioning of the mechanism is illustrated herewith. The arrangement is called a slip drive, and has been used to good advantage on machines of various types. The application of this type of drive will do away with the breakage caused by the machine becoming blocked and will permit the pulley to continue to revolve without the belt slipping off. The drive, as will be seen by inspecting the illustration, is from the driving shaft through a fixed arm and then through the loose pulley.

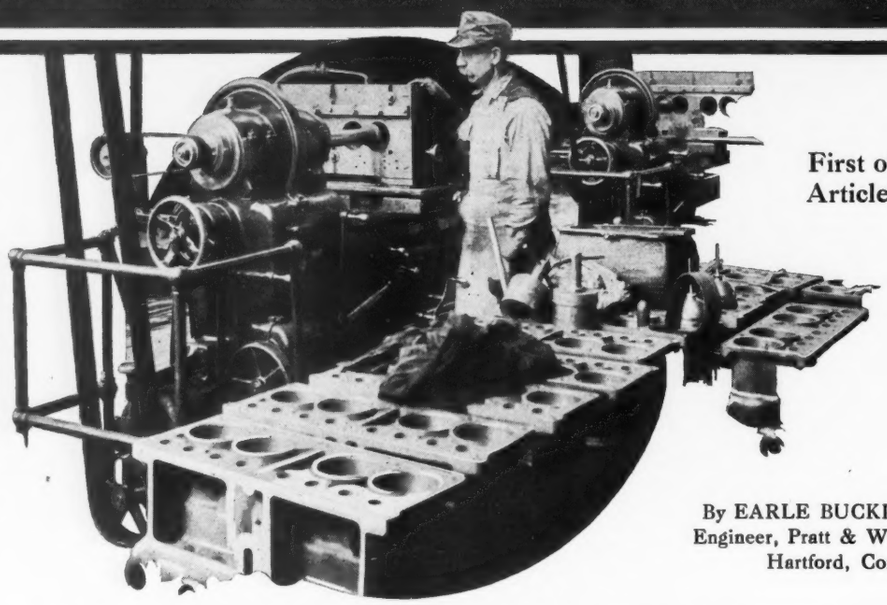
The construction of the arrangement is as follows: A machine steel disk *A* is bored out to fit the turned end of the driving pulley hub, to which it is either keyed or held by means of a drive fit. The driving arm *B* is secured to the driving shaft by a tapered pin, and carries a hardened tool-steel plunger, or detent *C*, backed by the pressure spring *D*, both of which are housed in a recess in the arm by means of the retaining screw *E*. A single spot is countersunk in the disk *A* for the purpose of receiving the point of the plunger, which should be a good fit in it. The pressure spring should be stiff enough to hold the plunger in the recess of the disk while the machine is being driven under a normal load. It will be apparent from the illustration that when the machine becomes blocked the plunger will slip out of its conical seat in the disk as the driving shaft continues to revolve, thus disconnecting the drive. The plunger will snap in and out of this recess at each revolution, and this clicking noise will attract the attention of the operator if his attention happens to be directed to some other machine at that particular moment.

* * *

The Navy Department has made comparative trials between one of the surrendered German U-boats which was built at Kiel in 1918, and the S-3, which was designed by the Navy Department and built at the Portsmouth Navy Yard. The two boats are practically the same in size, and the trials show the following results: The speed of the German boat was 13.8 knots on the surface and 7.8 knots submerged; the speed of the S-3 was 14.7 knots on the surface and 12.4 knots submerged. The German boat can cruise 8500 miles at 8 knots, and the S-3 can cruise 10,000 miles at 11 knots.

Equipment for Interchangeable Manufacturing

A Discussion of the Principles to be Considered in the Selection of Machine Tools and in Designing Jigs, Fixtures and Cutting Tools for Interchangeable Manufacture



First of Three Articles

By EARLE BUCKINGHAM
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IN the articles relating to interchangeable manufacturing published in preceding numbers of MACHINERY, an idea was given of the information required for interchangeable manufacturing, desirable lines to be followed in obtaining these data were indicated and proper methods of recording this information were described and illustrated. Even with the exercise of the greatest care in this preliminary work, many petty details will be overlooked; but the design and construction of the manufacturing equipment can be carried through with expedition and confidence as soon as this preliminary information is obtained. If time is important, the work of designing and constructing this equipment can be turned over to a large number of persons or to several different plants to develop independently. It is, of course, essential that a uniform method of interpreting drawings and tolerances be used, and that complete operation lists be furnished.

These operation lists should map out the plan of action for the selection or design of the equipment. Fig. 1 shows a form which has proved very satisfactory in service. The preliminary lists should give such descriptions of the special tools and gages to be made that their design can be readily developed. The final lists may refer to these tools and gages by number only. If these lists are kept up to date, they become a valuable key to all production.

Selection of Machine Tools

In order to insure ultimate economy, the proper choice must be made between standard or special machine tools. The amount and type of available equipment affects this decision. In general, standard equipment is advisable, although occasionally the reverse is true. For example, in the case of an extremely high rate of production, special automatic machines built to serve one specific purpose prove more economical. In other cases, a small special, single-purpose machine can be built as cheaply as a special fixture to be used on a standard machine tool.

The following factors must be taken into account if ultimate economy and high quality of product are to be secured. In purchasing new equipment its first cost must be considered. This, in itself, should never be the determining factor, neither should it be entirely ignored. The operation and maintenance costs are of far more importance than the first cost. These are important whether the equipment is old or new. If general data are compiled, in the manner described in the March number of MACHINERY, a convenient and reliable source of information will be at hand to assist in establishing the economical balance between the first cost and operating expenses.

In the course of time new demands are made of different classes of commodities. The typewriter, for example, was originally built to handle ordinary correspondence. Now it is also used in making up invoices and loose-leaf ledger sheets. In some cases, special machines are used for this purpose, but there are firms that cannot afford a double equipment of typewriters and to meet this demand, new features have been introduced on the machines, such as tabular stops, etc. The possibility of such modifications must never be overlooked. Therefore, another characteristic of the machine tool equipment is its adaptability. All other factors being equal, that machine which is the most adaptable to other operations should be chosen. In this connection, it is of interest to note that single-purpose machines are usually the more adaptable, and furthermore, that they often prove more economical in other ways. For instance, the writer knows of a watch factory which was engaged in making fuse bodies during the war. Some were made on semi-automatic turret lathes and others were machined on small bench lathes. The turret lathes practically completed the parts in two operations, while more than a dozen operations were required on the bench lathes. The parts produced on the bench lathes were not only more nearly identical than those produced on the turret lathes, but also cost less to manufacture. The turret lathes were purchased particularly for this job while the bench lathes had been formerly used in turning watch cases.

The machines selected must be sufficiently rigid to perform their task. The introduction of high-speed steels for cutters has created more severe conditions than formerly existed, and the improvement of the cutters in this respect has caused a great increase in the rigidity of many machine tools. It is interesting to compare the general construction of an earlier type of manufacturing milling machine which is shown in Fig. 2, with that of a more recent type shown in Fig. 5.

From the production standpoint, the most important factor of the machine tool equipment is the ease and facility with which it can be set up, adjusted, and operated. Several successive operations on simple single-purpose machines are often more economical than a single operation on a more

NAME OF PART _____ PART NO. _____
MATERIAL _____ POUNDS PER _____ PIECES
DATE _____ SHEET NO. ____ OF ____ SHEETS

OPER. NO.	NAME OF OPERATION, HOLDING POINTS, ETC.	MACHINE	JIGS AND FIXTURES	CUTTERS	MAN HOURS PER 100 PIECES	MACH. HOURS PER 100 PIECES	PIECE PRICE PER 100 PIECES	GAGES		
								WORKING	INSPECTION	MASTER

Machinery

Fig. 1. Operation Sheets on which should be given Essential Information required in designing Special Tools and Gages

complicated machine. The actual production time of the latter may be much less than that of the former, but when it is stopped for adjusment and setting-up, the loss of production is correspondingly greater. Furthermore, the multiplicity of adjustable parts makes it necessary to stop for readjustments more frequently. It should not be assumed from this that single-operation machines are always the most economical, because on parts having liberal tolerances the reverse is true.

Design of Jigs and Fixtures

Jigs and fixtures are provided to assist in machining specific surfaces on specific parts, and their design depends to a large extent upon the design of the parts to be machined. There are, however, a number of general principles which apply equally to all types of fixtures. The holding or register points of tools and fixtures for all finishing cuts should be identical with those surfaces from which the dimensions are given on the component drawings. On roughing cuts, these holding points are of lesser importance, yet it is good practice to maintain, as far as possible, the same register points on both roughing and finishing cuts. The stud shown in Fig. 3 is presented as a simple example to illustrate this principle. It will be noted that the dimensions of length, except the depth of the counterbore, are all given from one end, that the depth of the counterbore is given from the opposite end, and that the part is to be machined all over. This part can be machined in a single operation on a screw machine by means of the tools illustrated in Fig. 4.

Surface *Y* of the cutting-off tool *A* establishes the register point for forming tool *B* and facing tool *C*. Surface *X* of the forming tool is adjusted in relation to surface *Y* of the cutting-off tool so that the length of the stem on the work will be as given on the component drawing. Surface *Z* of the facing tool is also adjusted in relation to surface *Y* of the cutting-off tool in order to maintain the proper over-all length of the piece. Counterbore *D* is provided with an adjustable stop *E* which registers against the forward end of the stud. The contact surface of this stop is adjusted in relation to surface *W* of the counterbore so as to maintain the prescribed depth.

If the bottom of this counterbore were located on the component drawing from the end of the stem, the stop on the turret would be adjusted so that surface *W* of the counterbore would keep its proper position in relation to surface *Y* of the cutting-off tool. Stops on the cross-slide carrying the forming tool control the outside diameters.

The next question that arises is the proper limit at which to set the tools. There are four main sources of variation to consider: First, the errors resulting from imperfections in the machine; second, those caused by wear on the cutting edges of the tool; third, those due to errors in the tools; and fourth, those caused by improper setting of the raw material in their holding devices. In the following, only those variations which affect the lengths of the stud will be dealt with.

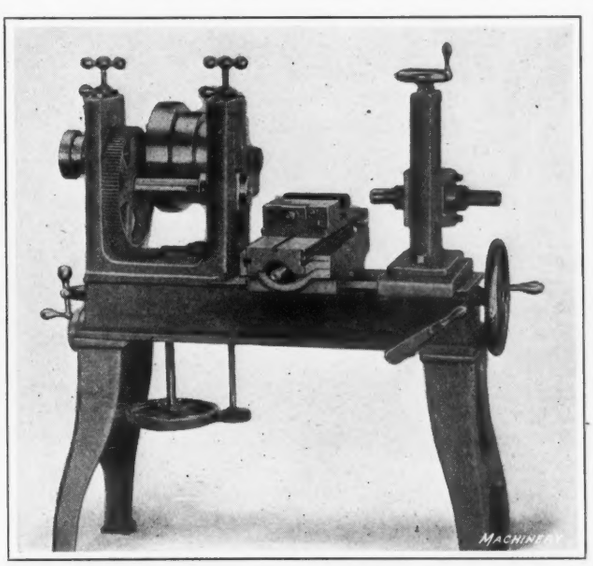


Fig. 2. Early Type of Manufacturing Milling Machine

Results of End Play in the Machine Spindle

Referring to Fig. 4, any end play in the spindle of the machine will reduce the distance between the surfaces machined by tools *A* and *C*. If the forming and cutting-off tools are held rigidly together, this end play will not affect the distance between the surfaces machined by tool *A* and surface *X* on tool *B*. If, however, these two tools are independent of each other, as shown in the illustration, this end play may cause a variation in either direction. In the first case mentioned, a male dimension is dealt with and inaccuracies in the action of machine tools cause a minus variation in such a length whether the cutting tools are independent of each other, or combined in a single tool. Similarly in the case of a female dimension, it is evident that the variation will be plus. End play in the machine will not affect the depth of counterbore when the tool is self-registering as shown; thus a self-registering tool often produces more accurate results than one controlled by stops on the machine itself.

Wear on the cutting edges of tools *A* and *C* will increase the distance between surfaces *Y* and *Z*, but if the wear on surfaces *Y* and *X* is uniform, no variation will develop from this source. If it is not uniform, the variation may be in either direction. As surface *W* becomes worn, the distance, between this surface and the contact surface of stop *E* decreases, that is, of course, assuming that there is no appreciable wear on the contact surface of the stop.

Considering only the first two factors, that is, imperfections in the machines and wear on the cutting edges of the tools, the original setting of facing tool *C* should be as near to the minimum limit as the accuracy of the machine permits; the setting of forming tool *B* should be at the mean dimension until actual practice demonstrates a tendency to vary more in one direction than the other; while the setting of stop *E* on counterbore *D* should be as near to the maximum limit as possible. This will give the maximum time between readjustments. The conditions created by errors in the tools themselves will be dealt with later in the article.

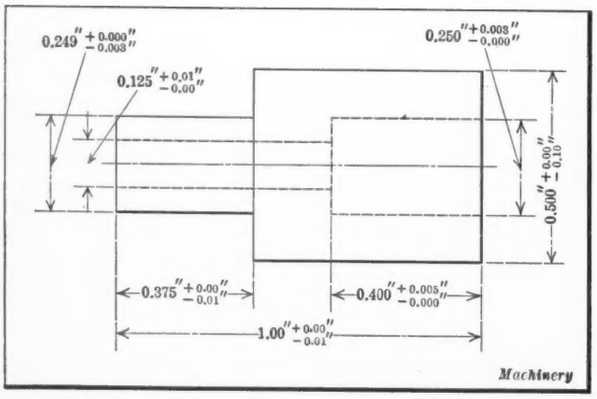


Fig. 3. Drawing of Stud machined in One Operation on a Screw Machine

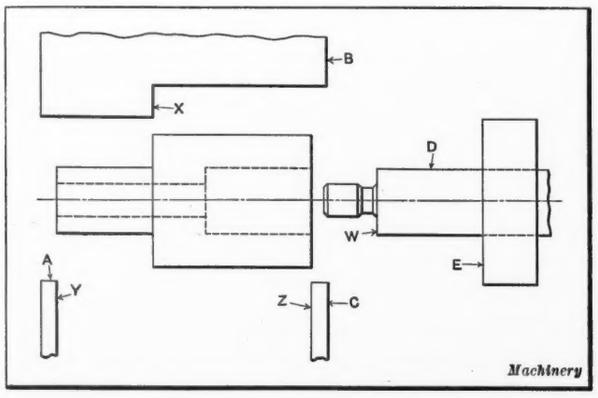


Fig. 4. Diagrammatic Illustration of Tools used in machining Stud

Results of Wear on the Cutting Edges of Tools

It is thus evident that the effect of imperfections in the operation of machine tools, when the cutting tools are located by stops on the machine, is to cause a plus variation on female dimensions, a minus variation on male dimensions, and a plus and minus variation on neuter dimensions, such as the horizontal distance between surfaces *Y* and *X*, which cannot be strictly classified as either male or female. In other words, imperfections in machine tools, such as end play, etc., cause additional metal to be removed. In a similar manner, the wear on the cutting edges of the tools causes a minus variation on female dimensions, a plus variation on male dimensions, and a plus or minus variation on neuter dimensions. In the last case, if the cutting edge of one tool consistently wears faster than that of the other, the variation will run in only one direction. Assuming that surface *Y* wears faster than surface *X*, the variation will be plus. If the wear is equal, no variations develop from this cause. In other words, the wear on the cutting edges of the tools usually causes a variation in the reverse direction from that caused through the presence of imperfections in the machine tools.

The same principles apply equally to all types of operations such as turning, milling, planing, grinding, profiling, shaping, boring, etc. In order to establish the proper dimensions for the holding and registering points on tools and fixtures, it is necessary to analyze each particular surface carefully and proceed accordingly.

In the above example, errors due to the improper setting of the stock in the holding device are not present. In the case of milling, drilling and other similar operations, where the parts are handled singly instead of being machined from bar stock, this is one of the most serious problems. Chips are apt to remain on the locating points or the operator may fail at times to seat the piece properly before clamping. In the case of drilling, this results in the improper location of the holes. In the case of other operations, it will result in removing additional stock. Proper training of the operator is the only cure for this fault. Correctly designed fixtures greatly reduce the chances of these errors, yet, as in other matters, it is not possible to make everything so that it will be entirely fool-proof.

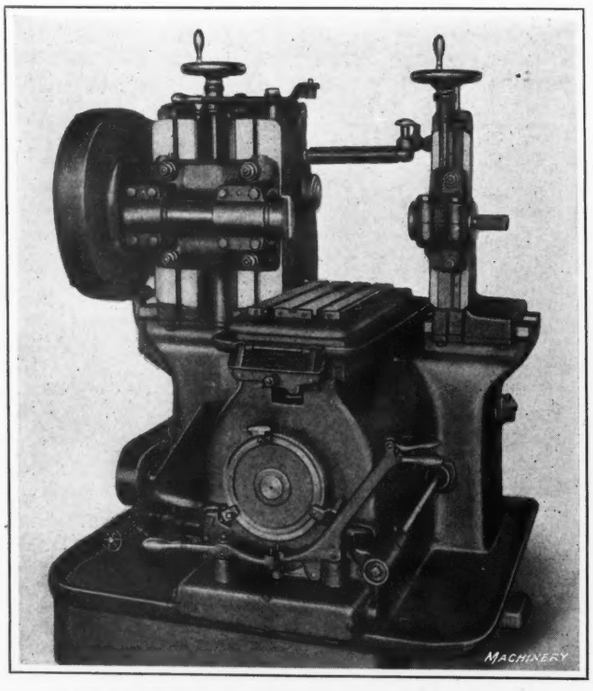


Fig. 5. Modern Type of Manufacturing Milling Machine

Factors to be Considered when Designing Fixtures

The second important factor of the design of fixtures is their operation in service. The selection of the proper locating points controls in a large measure the uniformity of the product. The facility with which these fixtures may be operated determines to a great extent the rate of production. The direct labor cost of production is also greatly reduced with quick-acting jigs and fixtures. On the other hand, such equipment is often very expensive, and therefore the total output involved determines the amount of money which may be economically expended on the equipment. In the case of a very small total output, little or no special equipment need be provided.

When continuous production is involved, every effort should be made in designing the equipment to have it operate rapidly. It should operate easily and with a single motion of the operator's hand if possible. Secondly, the fixture should open so that the part to be removed is accessible. Third, the position of such openings in relation to the cutting tools should be such that there is no danger to the operator. Whenever the operator is required to place his hand close to the cutting tool, he normally moves slowly and cautiously, thus reducing the rate of production. Fourth, all exposed sharp corners and edges on the fixtures should be eliminated to prevent injury to the operator. Fifth, the locating points should be accessible, to facilitate cleaning and the proper insertion of the work. Sixth, liberal chip clearances should be provided to facilitate cleaning the fixture and also to prevent marring the machined surfaces of the parts under the process of manufacture.

Examples of Efficient Fixture Design

Except for relatively large parts, careful study will make apparent a simple and effective means of clamping the work with a single motion of the operating handle. Loose nuts and screws should be avoided for clamping purposes whenever possible, as these are very slow to operate. A milling fixture which requires only a single motion to clamp is shown in Fig. 6. An assembly view of this fixture is shown in Fig. 8, and the details of its construction will be understood by reference to this illustration.

This fixture is used when milling the bottom, right- and left-hand sides of a small

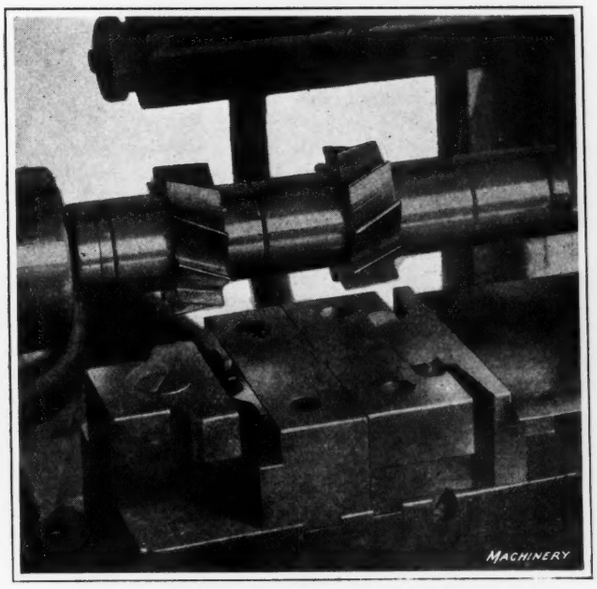


Fig. 6. Design of Milling Fixture in which Three Pieces of Work are clamped by a Single Motion

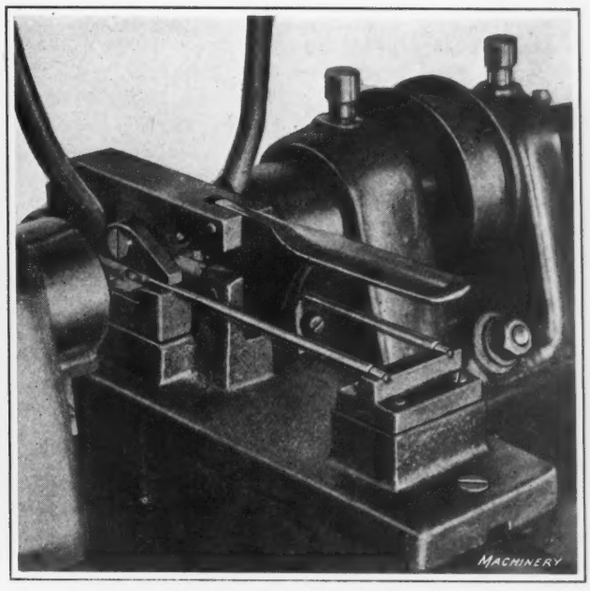


Fig. 7. Machine provided with Fixture used in Spline Milling in which the Work is Readily Accessible

forging in a single operation. The forging is first placed in the position indicated at *A* by dot-and-dash lines, where one side is milled. This piece is then advanced to position *B*, where the opposite side is milled. It is then inserted at *C* in which position the bottom is milled. In actual operation, when the original piece is placed in position *B*, a second piece is placed at *A*, and when the original piece is moved to *C*, the second piece is moved to *B* and a third piece is placed at *A*. Thus three pieces are being machined at the same time. All three parts are clamped by one motion of the lever, *D* and *E* being fixed jaws and *F* and *G* clamping jaws. The cam which is attached to the operating lever draws back the jaw *F* and pushes forward the jaw *G*. The jaw *F* is designed so that it can rock, thus securing the parts at *A* and *B* with equal pressure regardless of the variations in size between the two pieces. This particular construction permits clamping in three places simultaneously with a single motion of the operating lever. Modifications may be made in this design which will permit clamping in three or more different directions when this is desirable or necessary.

Inaccessibility is one of the most common faults found with jigs and fixtures. Sufficient clearance should always be allowed to enable the operator to remove the completed work readily and also to insert a new part and hold it in position while clamping. Careful attention to this point will greatly promote rapid production. Fig. 7 shows a spline milling fixture which affords a simple example of this point. The construction of this fixture is shown in Fig. 9. Two pieces are held at one time, the pieces being clamped in position by a leaf. It will be noted that each piece is clamped in two places by a single operating lever. The leaf is hinged so that it may be thrown back out of the way when the work is being removed or inserted. The rapidity with which this can be accomplished is a means of increasing the production.

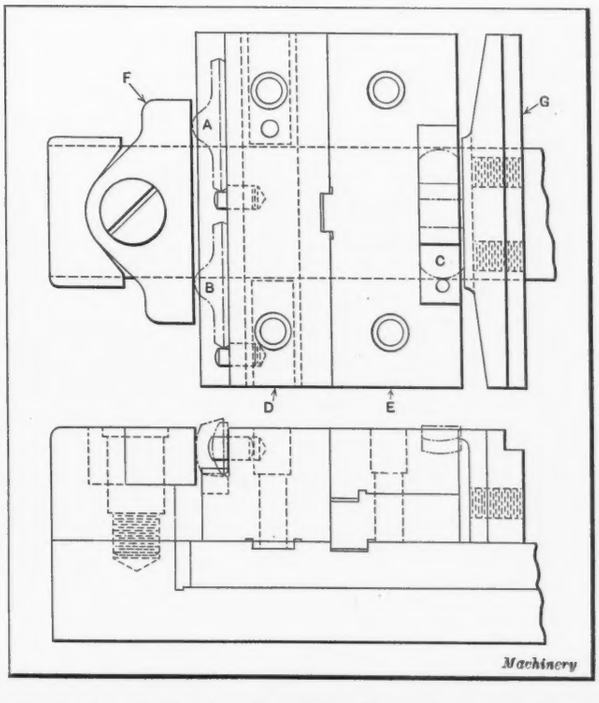


Fig. 8. Assembly Drawing of the Milling Fixture illustrated in Fig. 6

Providing Protection from Cutting Tools and Sharp Corners, and Accessibility of Locating Points

In many cases, standard machine tools are so designed that the table is well away from the cutting tool in its loading position. In the case of drill jigs, the operator withdraws them from beneath the spindle of the machine before he unloads them. Sometimes, however, the design of the machine tool or fixture is such that the fixture cannot be removed from under the cutting tools. In such cases, if the fixture cannot be designed to open on the side away from the cutting tool, provision should be made for rolling or rocking the fixture away from the tool. If this cannot be done, some safety device should be designed which will stop the cutting tool and prevent it from starting while the operator's hand is in any position of danger. Safety guards and automatic stopping devices on punch presses are good examples.

It is evident that the operator will handle a jig or fixture without sharp edges much more quickly and surely than one on which he is continually tearing his hands. It is the standard practice of most tool-rooms to remove all such corners carefully, whether the drawing of the fixtures specifies it or not. The locating points in the jigs and fixtures should be so placed that they can be readily reached. This not only facilitates the cleaning of the fixture but enables it to be more accurately made. It also allows any necessary corrections due to wear or change in dimensions to be quickly and economically made. These locating points should stand clear and be as nearly self-cleaning, as regards chips and dirt, as it is possible to make them.

Necessity of Providing Proper Chip Clearances

Careful consideration should always be given to the provision of suitable chip clearances. If this point is neglected, the operator will often spend more time in

removing the chips from the fixture than he does on any other operation. On the other hand, if he does not remove them, inaccurate work will result. Many ingenious devices have been developed for cleaning. A jet of compressed air or a stream of oil or soda water properly directed often accomplishes this task quickly and well, and this demands that the design of the fixture be such that the chips are readily carried away. A little attention to this point by the tool designer will often save hours of time later during production— time of both operator and machine. In Fig. 10 is shown a simple jig which illustrates, among other features, simple methods of obtaining chip clearances. The construction drawing of this fixture is shown in Fig. 11. The part to be drilled is located in one place by the tapered tongue *B* shown in section *A–A*, and is clamped by a leaf. The body of the jig is a skeleton frame which contains no pockets to catch the chips. The leaf swings open, thus allowing all chips to be easily brushed or blown out.

The following example shows the results actually obtained in production by attention to these details. A certain firm contracted to make 200,000 small pinions as shown in Fig. 12. It will be noted that three of the six teeth are partly removed. The pinions were made from brass pinion stock being extruded to form, after which they were drilled and cut off in an automatic screw machine, and counterbored in a drilling machine to remove the stock from three of the teeth. The drill jig first employed in the last operation was one with a leaf in which several pinions were held. It was designed and built without much thought, as the job seemed simple and unimportant. The parts were so small and difficult to handle rapidly and the chips were so troublesome that the best rate of production possible with this jig was about 160 an hour. This was so far under the estimated production that a serious loss on the contract seemed inevitable. After a little study, a new jig—incidentally a cheaper one than the original—was designed and built. This jig is shown in Fig. 13. A pair of parallel jaw pliers *A* was used as a basis. These had special jaws *B* inserted to hold the pinions, one of them carrying plate *C* which had three holes that served as drill bushings. Spring *D* which was attached to one jaw, opened the pliers, while the grip of the operator closed them and held the pinion in position. A cast-iron parallel *E* about two inches high was clamped to the table of the drilling machine, and two rods *F* which served as feet to level the device, were riveted to the handles of the pliers. The bottom of the pinion rested on the cast-iron parallel, while the top rested against the drill plate *C*. The operator handled this jig as follows: About half a dozen pinions were placed on the cast-iron parallel approximately an inch apart. The open pliers were placed over the first piece and then closed. The shape of the jaws insured that the piece when clamped would be in the proper position for the operation. The pliers were then slid under the spindle of the drilling machine and the pinion was counterbored. To unload, the operator moved the jaws away from the cast-iron parallel as he released his grip. The completed parts and all chips then dropped out, and he proceeded to pick up the next pinion. The rate of production with this jig was over 500 an hour, and nearly double the estimated output.

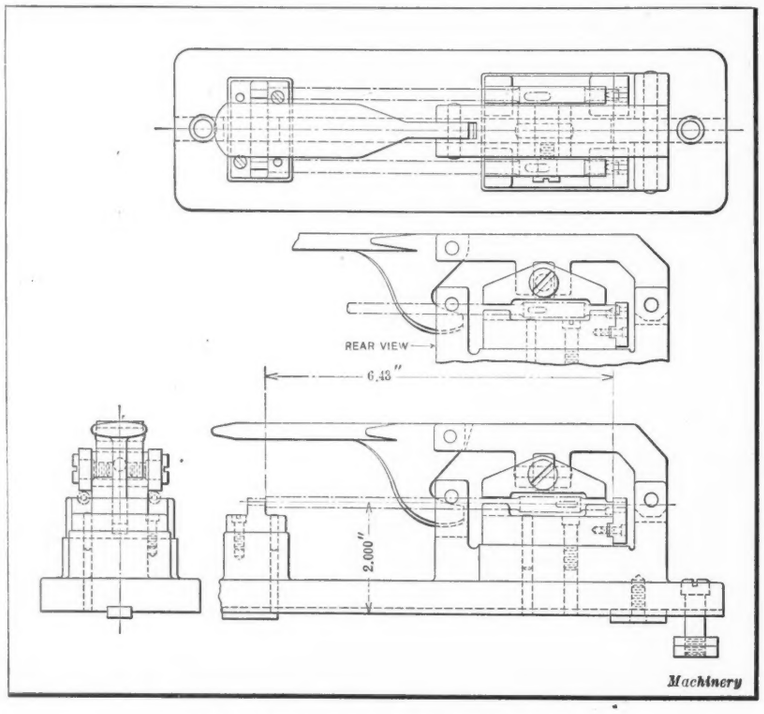


Fig. 9. Construction of Spline Milling Fixture

Needless to say, the greater the rigidity of the tools, the greater the accuracy of the product. Whenever possible, the pressure of the cutting tools should be withstood by a solid part of the fixture and not by a clamp. Fixtures which are permanently fastened to the machine should be sufficiently rugged to withstand all use and abuse. Independent jigs which must be lifted or turned over in operation should be as light as they can safely be made. The design in all cases should be as simple as possible because simplicity is a primary source of economy. This simplicity, however, is seldom attained spontaneously. It is the result of constant study and careful and painstaking development. It may be safely asserted that designs which are not simple are incompletely developed.

Economy in the construction of jigs and fixtures offers a field for standardization. Not only the various drill bushings, operation levers, drill jig feet, vise jaws, etc., but also the baseplates for jigs and fixtures, various clamping devices, leaves, etc., can be standardized to advantage. This is now common practice in many up-to-date tool-rooms.

Methods Employed in Manufacturing Fixtures

The information required on fixture drawings depends to a large extent upon the methods to be employed in the construction of these fixtures. One of two general methods is usually employed. First, the complete fixture may be made by one man or a small group of men working in close co-operation. Second, the work on all fixtures may be resolved into its elements and one man or one group of men may do only the work of a certain type, such as planing, milling, boring, etc.

Each method has certain advantages and certain disadvantages. Among the disadvantages of the first method are the following: When one man performs all types of operations, either the tool-room must be over-equipped with machinery or a considerable amount of time will be lost by the various men in waiting their turn to use certain machines. Again, few men are equally expert in operating all types of machinery. The use of this method prevents the specialization of the men on those operations in which they are most expert. In order to overcome the foregoing disadvantages, the second method has been used. This often results in reducing the amount of tool-room equipment and increasing the total output. On the other hand, the elimination of the disadvantages of the first method has resulted in the loss of many of its advantages. With the first method, the toolmaker takes a personal interest in the development and completion of a certain fixture. It is a complete mechanism in which he can take personal pride, and this advantage is lost by the adoption of the second method. Furthermore, a careful dis-

tinction must be made between working time and elapsed time. The adoption of the second method, while it often reduces the total working time required to complete tools, inevitably increases the elapsed time between the receipt of the order and the delivery of the completed fixture.

To operate successfully under the second method, a certain amount of work must be kept ahead of each operation. This means that although the machines and men may be kept busy, each piece of work must wait its turn at each operation. Thus, in many cases, the elapsed time required to complete the fixtures under the second method is more than double the elapsed time required under the first. For replacement work, which can be anticipated and started well in advance, and for new work when time is not essential, the second method is often the better. In other cases, if ultimate economy is desired, the first method must be employed. Take for example an emergency repair. If we balance the decreased cost in the tool-room under the second method against the increased cost of the idle time of productive machinery and labor, we shall find that we have lost more than we have gained. This holds true for the construction of equipment for a new product when time is essential.

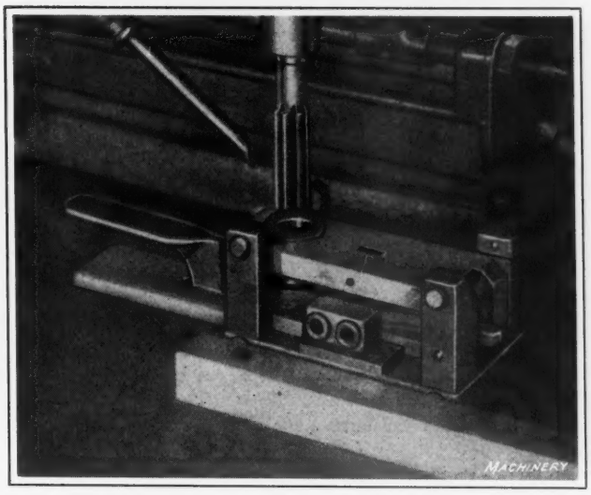


Fig. 10. Jig designed to permit Easy Removal of Chips during Various Operations on the Same Piece

When Tolerances should be Supplied on Fixture Drawings

The drawings required in the tool-room under the first method of production need be functional ones only. Except on important dimensions of functional locations, etc., tolerances will be of doubtful value. Detailed drawings of the individual parts of fixtures must be supplied, yet tolerances and clearances on these details can be safely omitted. On the other hand, drawings to be used with the second method should include tolerances on all but atmospheric fits. The direction of the tolerances on those surfaces which are fitted at assembly should leave surplus metal. Those parts which assemble without fitting should have their dimensions and tolerances expressed in the same manner as on the component drawings of the interchangeable product itself.

The establishment of the tolerances on the functional locations is identical in all cases. Variations in these dimensions will be reproduced in the product itself. The effect of these will be to reduce the manufacturing tolerance. It is obvious that these variations must be in that direction which will hold the product within the established tolerances. Naturally, then, these tolerances should be kept as small as possible. The fixtures are usually made but once, while the product must be reproduced many times over. The amount of this tolerance on the jigs and fixtures should be a fair percentage of the component tolerance and 20 per cent should be sufficient in most cases. It is clear that the location of drill bushings for holes which may vary 0.020 inch is not so important as for holes which can vary but 0.002 inch.

It should be kept in mind that in many cases adjustment is provided on the machine tools to align the work-holding fixture correctly in relation to the cutting tool. Such is the case on milling, planing, and other similar machine tools. In the case of jigs for drilling and boring, however, no such adjustment is possible. Such equipment must therefore be constructed with greater accuracy than milling fixtures. It is thus apparent that the original tolerances and clearances for those surfaces machined on this type of equipment must be designated on the component drawings with great care. It is obvious that if needlessly severe tolerances are required by the component drawings, the cost of the equipment will be greatly increased and no commensurate benefit will be derived from it.

Checking and Testing Jigs and Fixtures

The most effective method of checking jigs and fixtures is to set them up and make the required cuts on sample pieces. This, however, is not always possible and so model parts are a good substitute. Such parts are invaluable for checking purposes during the construction of any of the special manufacturing equipment. The final inspection of the completed fixtures should be a functional inspection only. The

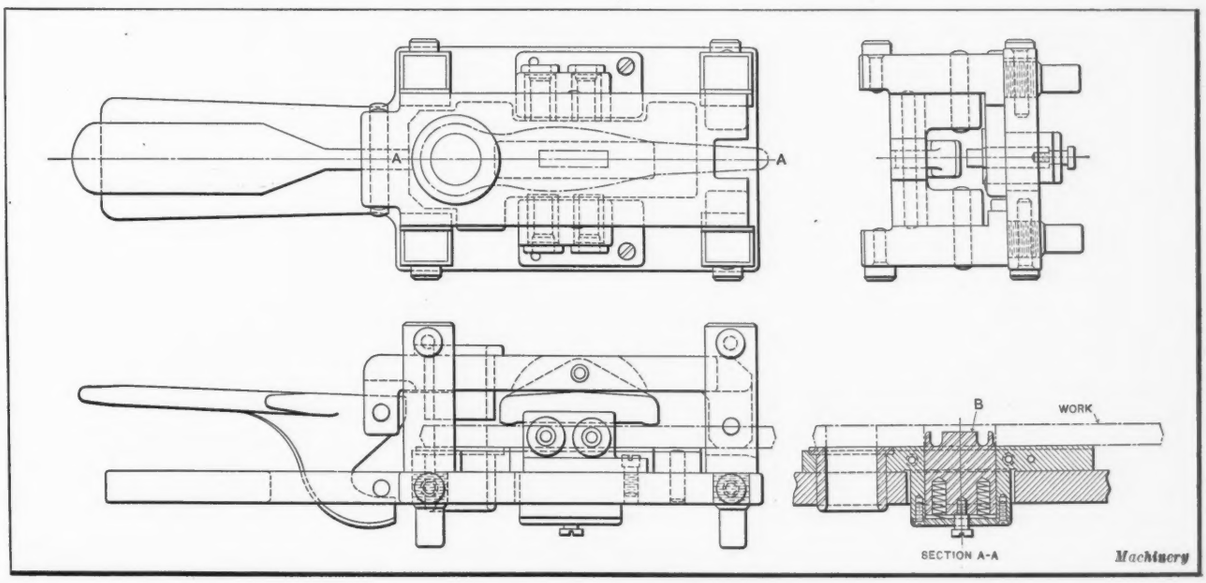


Fig. 11. Assembly Drawing of the Jig illustrated in Fig. 10

operating parts must function properly and the functional locations must bear the proper relation to one another. The component drawings, as well as the fixture drawing, should be consulted. Any fixture which will insure the proper machining of the component part is satisfactory as regards its accuracy. If the fixture drawing has been carefully completed, the information given there will indicate reasonable limits. If the fixture, however, exceeds those limits, but does insure the completion of the component part within the established tolerances, and without imposing over-severe conditions in the production, the fixture should not be rejected because of this technicality. It is well to keep a record of such deviations for reference. The purpose of this inspection is not to see how much fault can be found with the work accomplished, but to determine as surely as possible whether or not it will fulfill the purpose for which it is intended. This is never definitely determined until the fixture has actually produced satisfactory work.

Tolerances to be Allowed on Cutting Tools

In the early portion of this article, in connection with Figs. 3 and 4, several sources of variations in the product were mentioned. Some of these errors are fixed quantities, other are variable. In discussing the cutting tools, we will consider two sources of variations—the first variable, the second practically fixed. The first source of error, which has been previously mentioned, is that due to the wear on the cutting edges of the tool. This, as we have seen, results in leaving more metal on the piece. Disregarding all other factors of error, and assuming that the wear is equal on all surfaces, we should make the tools to the minimum metal sizes of the component drawings, in order to insure their longest life. When faces are neither male or female, the initial size of the tool should be the mean dimension. But if a tolerance of, say, 20 per cent of the component tolerance has been permitted on the jigs and fixtures, the cutting tools should be made approximately the same percentage inside the minimum metal sizes of the component, except those made to the mean dimensions. Tools made to such dimensions should produce work within the established limits. If, however, sample parts made by such tools are beyond the established limits, they will vary outside of the minimum metal sizes. In such cases the tools can be salvaged, as metal must be removed from the tools to correct this fault.

The second source of variation in the product is initial error in the size or form of the tool itself. Tolerances for tools should be established from experience gained in actual practice as carefully as the tolerances are established for the components themselves. Cutting tools must be replaced over and over again in the course of production. On one hand, in order to reduce the first cost of these tools, their tolerances should be as liberal as possible. On the other hand, to lengthen their life and thus reduce the number of replacements, they should be held as close to the minimum metal limits as other conditions will permit. The economical balance between these two factors establishes the proper tolerances. In practice, the fixed error due to inaccuracies

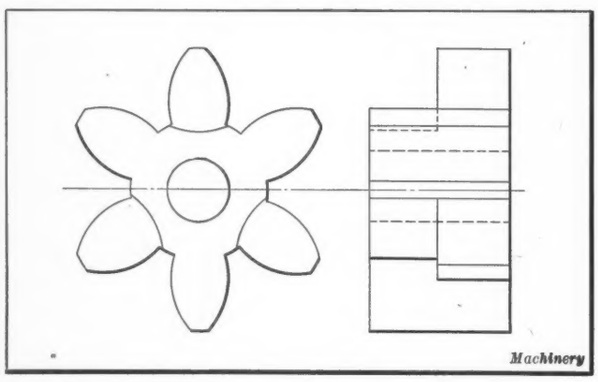


Fig. 12. Pinion having Three Teeth partially removed

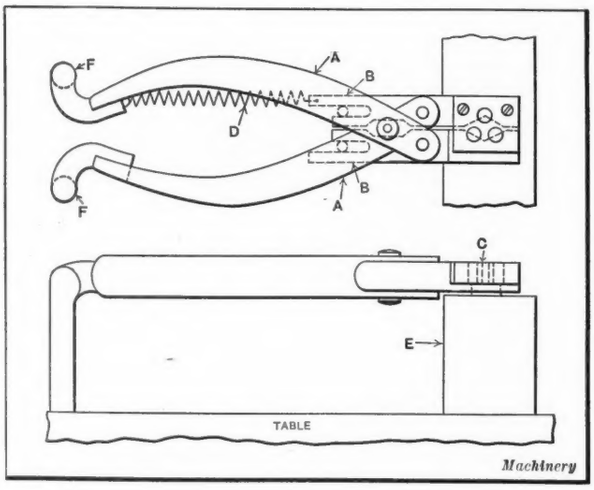


Fig. 13. Jig developed for handling Pinions in Counterboring Operation

in machine tools and fixtures can readily be determined after production is under way. This error, properly added to or subtracted from the minimum metal limit of the component, establishes the maximum metal limit of the cutting tool. This maximum metal limit should be the basic dimension of the cutting tool. The application of the tolerance then establishes the minimum limit of new cutting tools. Whenever the established tolerance on the component is exacting, the tool should be made adjustable if possible, thus enabling wider limits to be established on the tools, reducing their initial cost and prolonging their life. Such, for example, is the purpose of interlocking milling cutters.

Difficulty of Maintaining Tolerances on Tools Machining Several Surfaces

It is well to note that the more surfaces machined by a single tool, the more difficult it is to maintain close tolerances, either on the tool itself or on the product. Take, for instance, the cutting of a thread. If a die is used, the three main elements are carried on one tool; namely, the form, the lead, and the diameter. Adjustment for the diameter is possible, but the form and lead are fixed. Under present conditions, variations develop in the lead and shape when the tool is hardened and these are difficult and expensive to correct. As one die is replaced with another, these variations are different. If the tolerances on the component are sufficiently liberal, the use of dies is satisfactory. If they are severe, satisfactory dies are very expensive, although the direct production costs are low. In these cases, if the threads are milled or chased, the form alone is carried by the tool. Such a tool is readily and accurately made and maintained. The diameter is controlled by the setting of the tool, and is readily adjusted and readjusted. The lead is controlled by the lead-screw of the machine and is practically constant. Lead-screws can be obtained within any reasonable degree of accuracy.

Sufficient chip clearances must be provided on all cutting tools if a free cutting tool is to be obtained. The proper rake of the cutting edge should be determined as early as possible and carefully maintained. The design should be as simple and rugged as conditions will permit. The individual design and requirements of the cutting tools, of course, depend on the nature of the material to be machined and the methods of machining employed. The drawings of the cutting tools should be made with as much care and in conformity with the same basic principles as the component drawings themselves. When continuous production is involved, a constant supply of cutting tools must be provided, a supply which must be available for instant use with little adjusting or correction.

The next article on this subject will give examples of jig and fixture design, illustrating the application of the principles stated in the foregoing.

Chart for Determining Safe Loads of Round Steel Columns

By JOHN S. WATTS

THE accompanying chart, based on the American Bridge Co.'s practice may be used to determine the safe loads of steel columns up to 3 inches in diameter. The unit stress specified by this concern depends upon the slenderness ratio l/r of the column, l being the length of the column in inches and r the radius of gyration in inches. The allowable compressive unit stress S, in pounds per square inch, of columns where the ratio is between 60 and 120 is:

$$S = 19{,}000 - \frac{100 \times l}{r}$$

For the above ratios, the allowable unit stress varies 1000 pounds per square inch for each difference of 10 in the slenderness ratio, the allowable stress for a ratio of 60 or less being 13,000 pounds per square inch. When the slenderness ratio is between 120 and 200, the following formula applies:

$$S = 13{,}000 - \frac{50 \times l}{r}$$

By this formula the allowable unit stress varies 500 pounds per square inch for each difference of 10 in the ratio. The allowable unit stress for various ratios of from 60 to 200 are given in the table shown in connection with the chart, and proportional stresses should be allowed for intermediate ratios. The slenderness ratio should not exceed 120 for permanent work, but for work of a temporary nature the ratio may be larger, although it should not exceed 200.

Assume that the safe load for a column 2 inches in diameter and 56 inches long is to be found. Starting at the upper left-hand part of the chart, follow the perpendicular line marked 2, which represents the diameter of the column, to its point of intersection with the horizontal line marked 56, which represents the length of the column. Next draw a line from the upper left-hand corner of the chart through this point of intersection and extend it to the vertical line A. From this point draw a line to the lower right-hand corner of the chart and from the point where this line intersects the vertical line marked 2 draw a horizontal line to the right-hand edge of the chart, which will show the safe load to be approximately 24,500 pounds. It will be noted that the numbers along the line A which represent column lengths, refer only to the horizontal lines of the left-hand triangle, while the safe loads marked along the hypotenuse of the right-hand triangle refer to the horizontal lines marked on that triangle.

The slenderness ratio can be quickly determined by multiplying the value marked along line A nearest to the point where the line drawn on the left-hand triangle reaches this line by 1.33. In the example given this occurred near the horizontal line marked 84 so that the slenderness ratio equals $84 \times 1.33 = 112$. It is obvious that all values obtained on line A by the use of the chart vary as the slenderness ratios of the columns under consideration, and consequently are proportional to both the unit stress and the safe load. An idea of the unit stress can be obtained by noting the relative position of the intersection of the line drawn on the right-hand triangle and the vertical line representing the diameter of the column, with respect to the three stress lines on this triangle. In the given example, this intersection is a little above the line marked 7000 pounds per square inch, so that the unit stress is approximately 8000 pounds per square inch. If the size of the chart will allow, stress lines may be drawn to represent each variation of 1000 pounds, although this is not absolutely essential.

When the length and load of a column are specified, the necessary diameter can be readily determined by trial. It may also be found by stretching a thread from the upper left-hand corner of the chart to the lower right-hand corner, and then by means of a pencil, pushing the thread up or down, keeping the pencil on line A until the vertical line in the left-hand triangle nearest the intersection of the thread and the specified length line, indicates the same diameter as the vertical line on the right-hand triangle nearest the intersection of the thread and the specified load line. When the intersection of the length and the diameter lines occurs above the line marked $l/r = 60$, the safe load is found by following down the line indicating a unit stress of 13,000 pounds per square inch, to its intersection with the line giving the diameter of the column. This is because the allowable unit stress for columns having a slenderness ratio of 60 or less is 13,000 pounds per square inch. From this, it is obvious that in each case the load given by the intersection of any vertical line in the right-hand triangle and the hypotenuse marked 13,000 pounds per square inch is the maximum safe load for a column of that diameter, regardless of the length of the column, although for slenderness ratios under 60, this provides a lower factor of safety than is allowed for larger ratios.

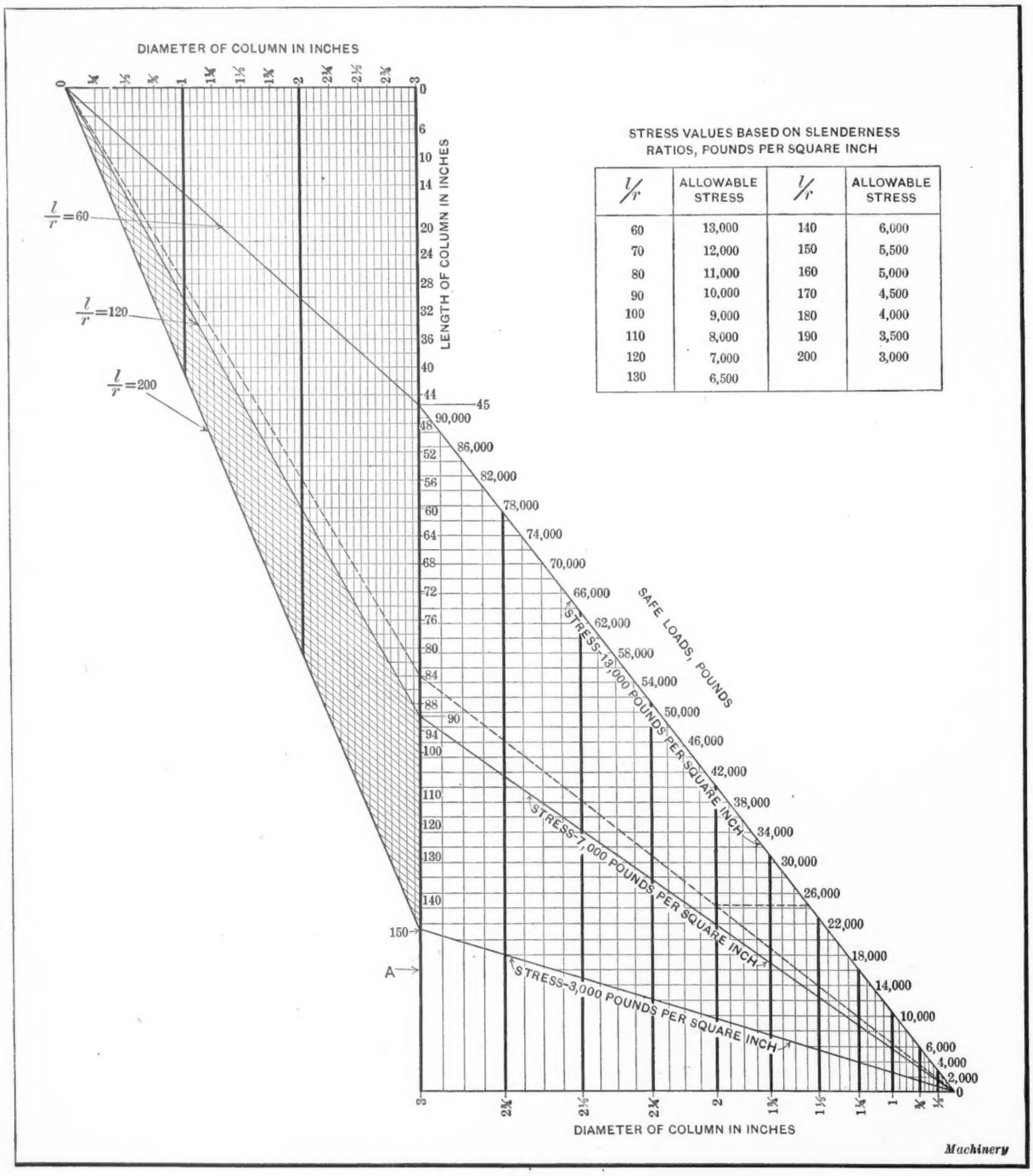
The chart is constructed as follows: The lower horizontal line of the right-hand triangle was first drawn, and as the safe load of circular bars varies as the square of the diameter, it was necessary for the length of this line to be proportional to the square of the largest diameter considered. In this case 3^2, or 9 inches, is the length of the line, which was drawn half size. Vertical lines representing the various column diameters, were then erected on this line at distances from its right-hand end, equal to the square of the diameter that each line represented. Since the greatest allowable unit-stress value used on this chart is 13,000 pounds per square inch, the safe load for a column 3 inches in diameter for slenderness ratios of 60 or less, is $0.7854d^2 \times 13{,}000$, or 91.892 pounds, d being the diameter of the column.

The vertical line A was next drawn to a length equivalent to this safe load, when laid out to some convenient scale; in this case, a scale of 1 inch = 16,000 pounds was used. At this scale the vertical line is 5.74 inches long. From the upper end of this line, the hypotenuse was drawn to the right-hand end of the horizontal base line, thus completing the triangle. The safe loads of a 3-inch diameter column for two other allowable unit stresses were then found. In this case, 3000 and 7000 pounds per square inch were the stresses selected, the corresponding loads being found to be 21,206 and 49,480 pounds, respectively. These values were also laid out on line A to the scale adopted for this line, and lines were then projected from these points to the right-hand corner of the triangle. Horizontal lines for each 2000 pounds of safe load were then equally spaced between the 3000- and 13,000-pound stress lines.

From the table shown in connection with the chart, it will be noted that the corresponding slenderness ratio for a unit stress of 3000 pounds per square inch is 200; for a unit stress of 7000 pounds, 120; and for a unit stress of 13,000 pounds, 60. Thus the points on line A from which the lines representing these stresses are drawn, also represent lengths of 3-inch diameter columns. The lengths of columns corresponding to each of the above ratios were accordingly calculated in order to lay out the length scale. For a circular

section $r = d/4$ in which d = the section diameter and r, the radius of gyration, so that for a 3-inch diameter bar, $r = \frac{3}{4}$ inch. Therefore, when the slenderness ratio is 200, $l = 200 \times \frac{3}{4} = 150$ inches; when the ratio is 120, $l = 120 \times \frac{3}{4} = 90$ inches; and when the ratio is 60, $l = 60 \times \frac{3}{4} = 45$ inches. The points where the stress lines join line *A* were then marked to indicate these lengths, this line being then subdivided to represent each difference of 2 inches in length. Thus the distance between the lines marked 45 and 90 was divided into 22½ equal spaces, and the distance between 90 and 150 was divided into 30 equal spaces. From point 45 upward, 22½ spaces were laid out to the same scale as the spaces between 45 and 90. At 0, the upper extremity of line *A*, a horizontal line 3 inches long, full scale, was drawn to the left and graduated into sixteenths of an inch. The length of either this line or the spaces into which it is divided does not affect the values obtained in the right-hand triangle, since the radius of gyration which controls these values varies directly as the diameter. The divisions between 0 and 90 are twice as great as those between 90 and 150, because the decrease in unit stress for each increase of 10 in the slenderness ratio between ratios 60 and 120, is twice as great as the decrease between the ratios 120 and 200.

As the distance between 90 and 150 was made proportional to the difference between the stresses 7000 and 3000 pounds per square inch, or 4000 pounds, and the distance between 45 and 90 was made proportional to the difference between 13,000 and 7000 pounds per square inch, or 6000 pounds, the distance between 45 and 90 is therefore 1.5 times the distance between 90 and 150. The latter represents 60 inches in length, and as the distance between 45 and 90 is 1.5 times as long, or $1.5 \times 60 = 90$ inches, the point 45 may be considered as the zero point, when laying out the portion of the chart, for slenderness ratios between 120 and 150. For this reason, the length lines between 90 and 150 were drawn parallel to the diagonal line $l/r = 60$.



STRESS VALUES BASED ON SLENDERNESS RATIOS, POUNDS PER SQUARE INCH

l/r	ALLOWABLE STRESS	l/r	ALLOWABLE STRESS
60	13,000	140	6,000
70	12,000	150	5,500
80	11,000	160	5,000
90	10,000	170	4,500
100	9,000	180	4,000
110	8,000	190	3,500
120	7,000	200	3,000
130	6,500		

Safe Load Chart for Round Columns, based on the Specifications of the American Bridge Co.

LETTERS ON PRACTICAL SUBJECTS

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FORMULA FOR TAPER MEASUREMENTS

Recently, while using the rule given on page 899 of MACHINERY'S HANDBOOK for finding the diameter of a disk to be placed in contact with a smaller disk of known diameter when measuring tapers, it occurred to the writer that a formula which did not involve a division of quantities would be easier to apply. Accordingly the following formula was evolved:

$$D = d \times \cot^2 \frac{180 \text{ deg.} - a}{4}$$

in which D = diameter of the large disk;
d = diameter of the small disk;
a = the angle to be measured.

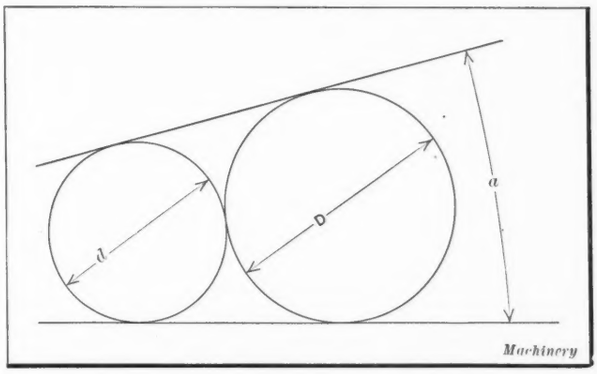


Diagram for Use in finding Diameter of Large Disk when measuring Tapers

The following example will illustrate the application of the formula: If the required angle a, as shown in the accompanying illustration, is 15 degrees and the diameter of the smaller disk is 1 inch, find the diameter D of the larger disk.

Substituting the given values in the above formula, we have:

$$D = 1 \times \cot^2 \frac{180 \text{ deg.} - 15 \text{ deg.}}{4}$$

$$= 1 \times (1.1403)^2 = 1.3002$$

From this example it will be seen that D may be obtained by comparatively simple arithmetical operations. This formula may be given in the form of a rule as follows: Subtract the required angle from 180 degrees, divide by 4, find the cotangent corresponding to this angle in a table of trigonometrical functions and multiply the square of this cotangent by the diameter of the small disk.

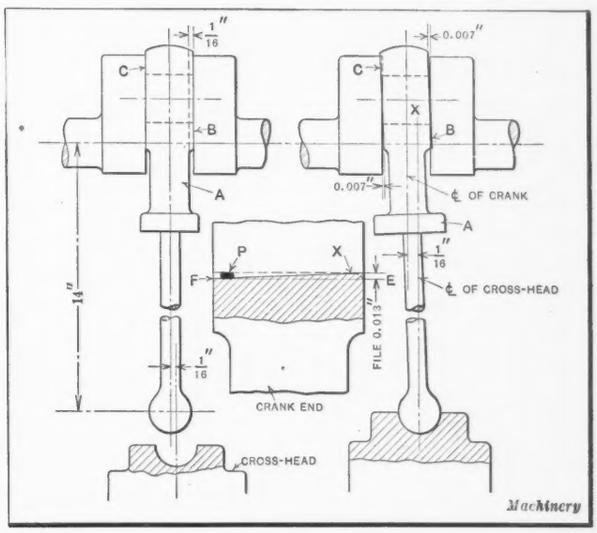
Ecorse, Mich. HERBERT BOLD

FITTING CONNECTING-RODS

It frequently happens that the fitting of connecting-rods to crankpins results in side play due to inexperience or poor judgment in aligning the connecting-rods with the cross-head center. In the case of punch presses and other similar crank-operated machines, the writer has frequently noticed a space permitting a play of as much as 5/64 inch on a crankpin 1¾ inches in diameter.

A method commonly employed when fitting ball-end connecting-rods is to first fit the crankshaft in its bearings and then fit the connecting-rod end A, with its cap, to the crankpin. The cross-head is next scraped to fit its slide and then connected with the connecting-rod end. It is during the latter procedure that the trouble occurs, for it will usually be found that the cap bears heavily on the side C and the body part of the rod end on side B, and in order to correct this, the two points are filed, but the trouble is not immediately eliminated; it will be found that side B continues to bear, and by the time the filing has produced the desired results, a full 1/16 inch will be filed away, and the result will be excessive side play in the bearing.

The following method for making the connection may be criticized as theoretically wrong; nevertheless, it has been found to work correctly. First, fit the cross-head into its position in the slide and then screw the rod into the bearing end A. After bluing the crankpin and the sides, place the ball in its socket with its cap removed, and slide the cross-head, bringing bearing end A against the crank. Assuming that the center of the cross-head is offset 1/16 inch from the center of the crankpin, it will be necessary to file off the sides at C and B as shown to allow the crank-end to strike the crankpin, which will occur at a point X. At a corresponding point near the opposite edge of the bearing (see enlarged view) place a piece of putty, as at P. Then slide the cross-head forward again until the crank-end strikes the pin and flattens the putty to a thickness which will indicate the amount of metal that must be filed from the bearing. With a 14-inch connecting-rod and a bearing 3 inches wide, this thickness will be about 0.013 inch, as is graphically shown by the broken line EF. In removing this metal, bevel the corner at X as shown, so as to assist in determining the depth of metal to be removed, then by using a 14-inch coarse half-round or bastard file, the metal can be readily removed to within the scraping limit. The cap must be treated in the same way. In fitting up the rod ends, there



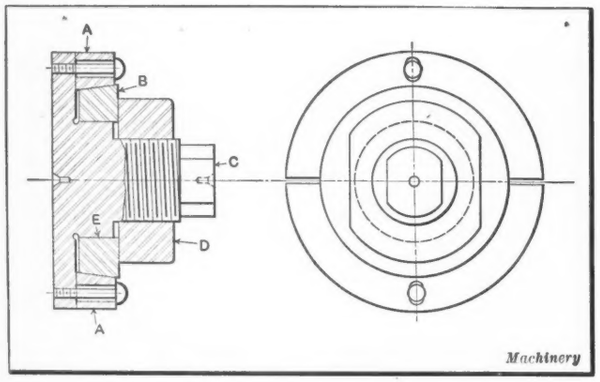
Illustrating Method of fitting Connecting-rods so as not to cause Side Play

should not be any side play, although the diagonally opposite sides will show a space about 0.007 inch wide, corresponding to the amount that was removed in order to get the ball end to swing over 1/16 inch.

San Francisco, Cal. M. JACKER

EXPANDING CENTER PLUG

The expanding center plug shown in the accompanying illustration is used when grinding the outside of a long-stem gear which is counterbored at the large end. Since this counterbore is used as a running surface for a set of ball bearings, which hold the gear in position when assembled, it was



Expanding Center Plug used in grinding Long-stem Gears

deemed advisable to use this as a working point for the head end when finish-grinding the stem. The main body of the fixture consists of a large flange *C* whose diameter equals the low limit dimension of the counterbore, and a stem which is threaded for a nut *D*. The threaded end is flattened as shown to suit a standard wrench. The flange is ground at *E* to fit the solid ring *B*, which is tapered to match the expanding members *A*. Two screws, which pass through loose slots, hold parts *A* in position and yet allow for expansion. All parts are hardened and ground.

The large end of the plug is inserted into the counterbore of the gear and the nut tightened. This forces ring *B* down, which, in turn, causes the parts *A* to expand outward and grip the gear firmly. The drilled center in part *C* and the one in the end of the stem are used as supporting points while grinding. Variation in the size of the counterbore is thus taken care of, and at the same time the gear is accurately centered.

Cleveland, Ohio. HARDIN D. THWEATT

DIES FOR DRAWING A UNIVERSAL JOINT COVER

Some of the more interesting dies used in forming the universal joint cover shown at *D* in Fig. 2 are described in this article. The shell is drawn from metal 0.166 inch thick, the blank being 8 inches in diameter. The die employed in the blanking operation is of simple construction and does not require special description. The second operation on the shell is performed by the push-through die shown at the left in Fig. 1. The blank is located on the die by means of the gage ring *A* which is attached to the die-block *B* and holds the drawing ring or die *C* in place. The drawing ring has a 30-degree angle and a liberally rounded corner over which the shell is drawn. There are three radial holes *D* in the die-block, which hold spring-actuated strippers so that when the punch ascends after having formed the shell as shown, the strippers will operate and prevent the shell from adhering to the punch. The punch is also provided with a knock-out which operates in hole *E*, but in this particular die the knock-out is not necessary, as the shell is stripped from the punch by means of the spring-actuated device previously mentioned. The dies used in the third and fourth operations are not illustrated, since their general construction is similar to that of the die employed in performing the fifth operation. Reference to Fig. 2 will show at *B* and *C* the shape of the shell after each of these operations.

The fifth operation, besides further reducing the body of the shell, also starts a small reduction on the end, as shown at *D*, Fig. 2. The die shown in Fig. 1 which is employed for this operation is of the same construction as the other dies used in the forming operations, except that on account of the tapered end of the shell a gage ring is not required to locate it in the die. A knock-out is provided in the punch at *E* and also one in the die at *K*. The sixth operation consists of further reducing the small end of the shell, and the dies employed are of similar design to those previously described. The shape of the shell after this operation is shown at *E*, Fig. 2. It will be noticed in all of these reducing operations that the 5¾-inch diameter at the flared end of the cover has been maintained throughout.

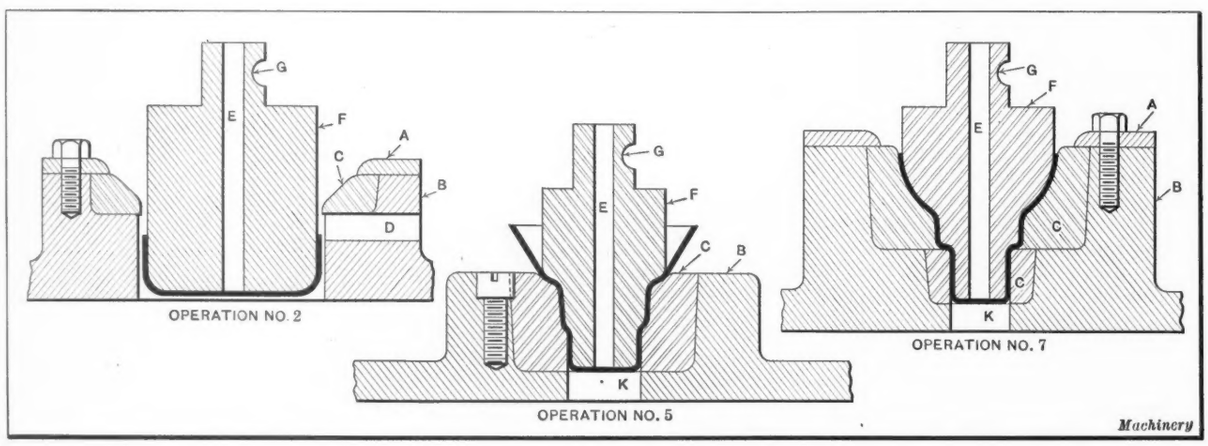


Fig. 1. Three Dies used in the Course of forming the Universal Joint Cover

The finish-forming die is shown at the right in Fig. 1 and is used in the seventh operation to expand the small end of the shell slightly and at the same time to form the bell-shaped flange to the dimensions shown at *F*, Fig. 2. This

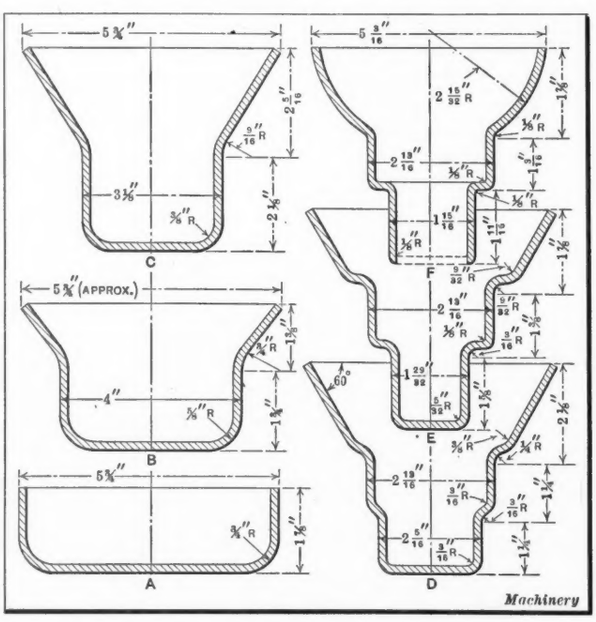


Fig. 2. Appearance of the Cover at Various Stages in the Forming Process

die consists of two separate die rings *C*, Fig. 1, the lower one of which is used for forming the straight part and the other for making the bell shape. The latter ring holds the lower ring in place and, in turn, is secured by means of gage ring *A* and machine screws, as shown. Both dies are carefully fitted in the cast-iron holder *B*, which should be of rather heavy construction on account of the considerable amount of force exerted on these tools. This will permit the die rings to be made comparatively light. The final operation on this shell consists of cutting out the bottom as indicated by the dotted lines at *F*, Fig. 2. This completes the forming of the shell, which must now be machined out in the small diameter before being ready for assembling.

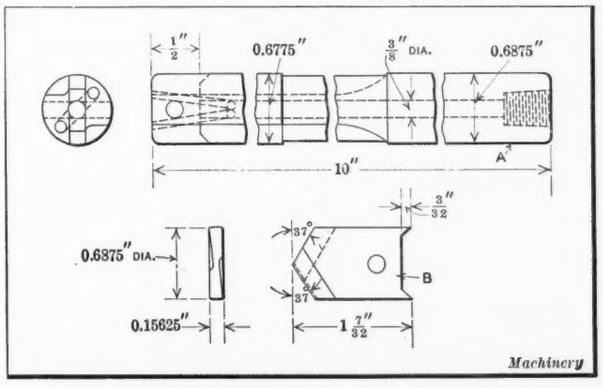
It should be stated generally that in drawing shells of this kind, it is good practice to keep the radii of the corners over which the metal is drawn quite large on both die and punch as this will prevent drawing thin places in the shell. In the dies illustrated and described in this article, a 1½-degree taper has been allowed for fitting the die rings into the die-block. All the dies should be hardened and ground at these angles and then carefully fitted in place. The punches are secured in the holder by means of a pin passing through the holder as indicated at *G* in Fig. 1. This provides a simple way of replacing punches without removing the holder from the press. In those dies where a knock-out is provided, as at *K*, it is, of course, understood that the familiar type of rubber buffer attachment is employed in drawing the shape.

Toledo, Ohio J. BINGHAM

DRILL FOR DEEP-HOLE WORK

Drills of the oil-tube type such as are used for drilling the through holes in lathe spindles or other similar deep-hole work are very expensive; consequently, if they cannot be used on work other than that for which they were originally purchased after they have become shortened as a result of the necessary frequent grindings, their use is exceedingly uneconomical, when the actual drilling service rendered is considered.

The tool shown in the accompanying illustration, which was designed to take the place of the regular type of oil-tube drill in order to reduce tool expense, has proved very satisfactory, having been found to maintain as high rates of production as the commercial type of high-speed oil-tube drill. This tool, which is intended for drilling a hole 11/16 inch in diameter, consists of a machine steel shank *A* and a high-speed steel cutter *B*. The cutter is inserted in the slot at the left-hand end of the shank and fastened securely in place by a taper pin. The chips are cleared from the



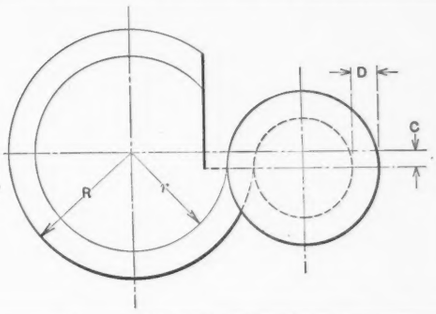
Details of Tool designed for Deep-hole Drilling in Steel

tool effectively by being forced back through the flutes on the shank by a cutting lubricant conducted to the cutter through the 3/16-inch longitudinal hole in the shank which connects with the two ⅛-inch holes at the cutter end. As the inserted cutter of high-speed steel is small and can be readily replaced when worn, it is evident that this type of tool is economical to use as well as inexpensive to make. B. R.

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR AUTOMATIC SCREW MACHINES

The accompanying table gives two dimensions *R* and *C* of circular forming tools which are constant for various sizes of Brown & Sharpe, Acme, and Cleveland automatic screw machines, and formulas for determining radius *r*. This radius varies according to radius *R* of the forming tool, the offset *C* and the difference *D* between the two radii on the

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR VARIOUS TYPES OF AUTOMATIC SCREW MACHINES



Make of Mach.	Size of Machine	R Inches	C Inches	r Inches
Brown & Sharpe	No. 00	0.875	0.125	$\sqrt{(0.8660-D)^2+0.0156}$
	No. 0	1.125	0.15625	$\sqrt{(1.1141-D)^2+0.0244}$
	No. 2	1.50	0.250	$\sqrt{(1.4790-D)^2+0.0625}$
Acme	No. 51	0.75	0.09375	$\sqrt{(0.7441-D)^2+0.0088}$
	No. 515	0.75	0.09375	$\sqrt{(0.7441-D)^2+0.0088}$
	No. 52	1.0	0.09375	$\sqrt{(0.9956-D)^2+0.0088}$
	No. 53	1.1875	0.125	$\sqrt{(1.1809-D)^2+0.0156}$
	No. 54	1.250	0.15625	$\sqrt{(1.2402-D)^2+0.0244}$
	No. 55	1.250	0.15625	$\sqrt{(1.2402-D)^2+0.0244}$
	No. 56	1.50	0.1875	$\sqrt{(1.4882-D)^2+0.0352}$
Cleveland	¼"	0.625	0.03125	$\sqrt{(0.6242-D)^2+0.0010}$
	⅜"	0.84375	0.0625	$\sqrt{(0.8414-D)^2+0.0039}$
	⅝"	1.15625	0.0625	$\sqrt{(1.1546-D)^2+0.0039}$
	⅞"	1.1875	0.0625	$\sqrt{(1.1859-D)^2+0.0039}$
	1¼"	1.375	0.0625	$\sqrt{(1.3736-D)^2+0.0039}$
	2"	1.375	0.0625	$\sqrt{(1.3736-D)^2+0.0039}$
	2¼"	1.625	0.125	$\sqrt{(1.6202-D)^2+0.0156}$
	2¾"	1.875	0.15625	$\sqrt{(1.8685-D)^2+0.0244}$
	3¼"	1.875	0.15625	$\sqrt{(1.8685-D)^2+0.0244}$
	4¼"	2.50	0.250	$\sqrt{(2.4875-D)^2+0.0625}$
	6"	2.625	0.250	$\sqrt{(2.6131-D)^2+0.0625}$

Machinery

work. The formulas were obtained by substituting the values for radius *R* and offset *C* in the formula

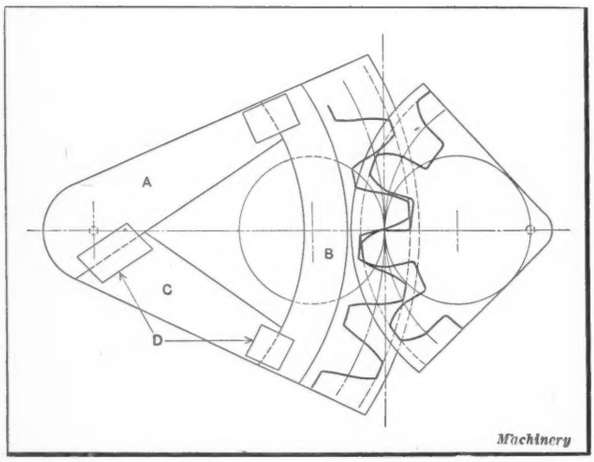
$$r=\sqrt{(\sqrt{R^2-C^2}-D)^2+C^2}$$

and simplifying. This formula is given in MACHINERY'S HANDBOOK on page 826.

Kenmore, N. Y. FELIX E. AVERILL

TESTING TOOTH OUTLINE OF SPECIAL GEARS

On page 327 of the December number of MACHINERY, a method of testing the tooth outlines of special gears by means of cardboard templets was described. The writer here presents another good method of doing this which does not require the making of templets. First make a pencil drawing showing a portion of each gear with the teeth engaged. The teeth of the gears should, of course, be developed with the special generating circle or curve employed in designing them. Care should be taken to make this drawing to a sufficiently large scale to permit accurate laying out of the profiles. Next ink in the center lines, pitch circles, and indicate the arcs of approach and recess. After this has been



Tracings employed as Templets in testing Gear-tooth Profiles

done, an ink tracing should be made of each gear segment on separate sheets, showing the centers, pitch circles and teeth.

If the tracing is a large one, strips of cardboard should be pasted on as shown at *A*, *B*, and *C*, in the accompanying illustration, and if necessary a short piece should also be pasted over each joint as at *D*. The illustration shows the traced segments pinned to their respective centers on the drawing and overlapping each other at their tooth ends. Now by turning the segments with their teeth engaged, any interference can be readily detected. This method also enables one to compare the tooth contact point with the arcs of approach and recess, which show through the tracing from the paper drawing.

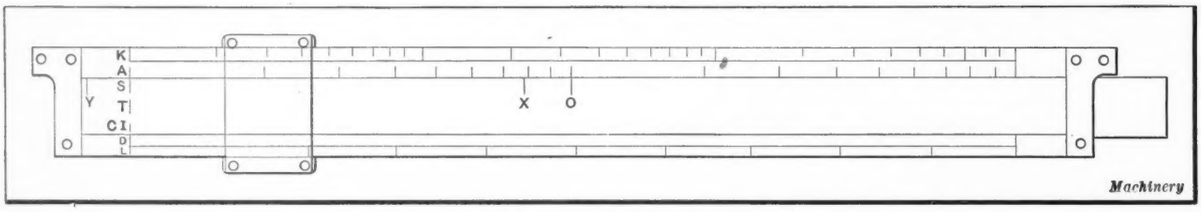
San Francisco, Cal. M. JACKER

SIMPLIFIED METHOD OF FINDING AREAS OF CIRCLES WITH POLYPHASE DUPLEX SLIDE-RULE

Since the polyphase duplex slide-rule has come into such general use among engineers and designers, an arrangement whereby a mathematical computation commonly performed with this rule may be considerably simplified may be of some interest. In finding the area of a circle using a duplex rule of the type shown in the accompanying illustration, it becomes necessary to mentally carry the square of the diameter or radius of the circle while turning the rule over to refer to the scales on the other side. If a provision were made whereby a constant were marked on the scale it would obviate this inconvenience and greatly simplify the process. On the common type of duplex rule, the scales are arranged on one side as follows: *K* or cube scale at the top of the rule; next *A*, or square scale; *S*, or sine scale; *T*, or tangent scale; *CI* scale (*C* scale inverted), for reciprocal work; *D*, the full-length regular *D* scale; and *L*, a scale of equal parts, or logarithm scale. The opposite side of the rule has the following scales: *CF* and *DF* (*C* and *D* scales folded); *CIF*, or *C* scale inverted and folded; and regular full-length scales *C* and *D*. Folded scales are those in which the graduations begin and end approximately at the center of the rule, the scales being so placed as to bring the division π in line with the index marks on the lower *D* scale.

The operation of finding the area of a circle with this rule is to set the runner so that the hair line is on the diameter of the circle on the *D* scale, using the side first mentioned and reading the square of the diameter on the *A* scale. It is then necessary to turn the rule over and set figure 4 on the *C* scale directly over the π mark on the *D* scale. This brings the right-hand index over graduation 0.7854; the answer is read on scale *D* directly under the square of the diameter of the circle on scale *C*.

In laying out a constant such as previously suggested, set the dividers to the distance from 4 to π on either scale *C* or *D*, and after marking this distance on some plane surface, bisect carefully. With the aid of the dividers lay off this distance to the left of the left-hand index mark on the *S*, or sine scale, and scribe as at *Y*. Since the square scale *A* contains two complete scales, an index must be scribed on the *S* scale under the central 1 of the scale *A*, and to its left another constant scribed as shown at *X*. In scribing these marks on the central part of scale *S*, the end index marks should align with the corresponding marks on the square scale, using, of course, the same setting of the dividers as before. When computing the area of a circle on a slide-rule, which has been scribed as just mentioned, the process is as follows: Set the runner with the hair line superimposed on the diameter mark of scale *D* as before; then operate the slide until the proper index on scale *S* lies under the hair line of the runner and read the answer on scale *A* directly over the constant. The distance of the constant from the index marks on the *S* scale is obviously one-half the distance from 1 to 0.7854 on the *C* or *D* scales, since the square scale is but one-half as long as the *C* or *D* scales.

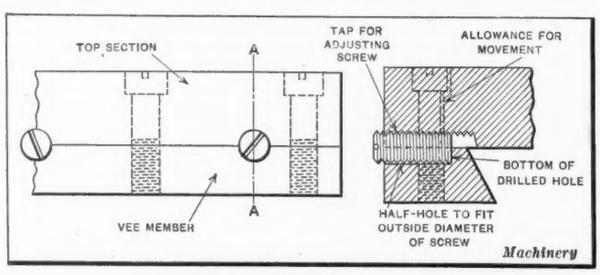


Polyphase Slide-rule with Constants for obtaining Areas of Circles

Decatur, Ill. WARREN ICHLER

ADJUSTABLE V-SLIDE

The built-up type of V-slide here illustrated presents a type of gibbing arrangement which, on account of its simplicity and strength of construction, should be of considerable interest. A valuable feature of this adjustable slide is that the clamping screws employed to hold the vee member to the top section, afford a means of maintaining the adjustment after it has once been made. In building up a slide of this type, clamp the vee member to the top part and lay out and drill the clamping screw holes; also lay out and prick-punch the location of the adjusting screw holes. These prick-punch marks should come on the dividing line between the two members so that when the pieces are unclamped, the location may be determined from either piece. After unclamping the pieces, clamp a piece of scrap stock to the upper member, and repunch the location of the holes so



Machine Slide with Adjustable Vee Member

as to form a center from which to drill the tapped hole. After drilling this hole, use a bottoming tap and run it in to about the depth shown in the sectional view. Repeat this sequence of operations for each adjusting screw employed. The half-holes in the vee member of the slide are next machined, using a scrap piece of stock as before and drilling to suit the outside diameter of the screws to be used. As shown in the illustration, these holes extend about two-thirds through the vee member and are bottomed to form a seat for the adjusting screws. Adjustment of this type of slide is accomplished by loosening the upper clamping screws and operating the adjusting screws until they bottom against the half-hole in the vee member. Continued adjustment of these screws will, of course, permit the slide to be tightened as required, to compensate for wear. It will be noted that the holes in which the clamping screws are tightened are elongated to allow this adjustment to be made. After the adjustment has been secured, the clamping screws are tightened and the entire arrangement firmly and positively locked.

The writer has used this type of slide on small grinding machine vises and lathes, and on jig work in which adjustable slides are required, and in every case it has proved highly satisfactory.

Allentown, Pa. JOE V. ROMIG

DANGER OF SNAP JUDGMENT IN ADOPTING EFFICIENCY METHODS

Many efficiency engineers assume to know more about a man's own production problems than he does himself. However, such assumptions are often dangerous, unless a thorough investigation is first made. The following example will illustrate this statement: Some time ago the writer had occasion to be in a shop where guns and rifles are made. This shop has been in successful operation for a great many years and is old enough to have a Brown & Sharpe universal milling machine without an overhanging arm—a machine that sold for $650 in 1879; hence, experience in good shop practice was not lacking. The gun barrels were turned in special barrel turning lathes. The writer was engaged in appraising the machinery, and found upon entering the gun barrel turning department that the gun barrel lathes were run with only one tool. As such lathes are used with four tools elsewhere, it was reasonable to assume that these machines were not strictly up-to-date and that a considerable amount should be allowed for depreciation. However, as it was apparent that the labor cost was lower per machine than it would have been with a machine using four tools, it was considered best to talk to the superintendent about this matter before making a decision. This is what the superintendent had to say when the subject of the gun barrel turning lathes was broached:

"Yes," he said, "we think that one man and four single-tool lathes is a better proposition for us than the same man with one or even two four-tool machines. Our turning costs are probably as low as any of our competitors', but even if they were not, the saving in the polishing department would make up for the difference. It is impossible to get four cuts on a piece to match up perfectly, and when they do not, it makes extra work in the polishing room. Another thing that probably hadn't occurred to you is that four tools are apt to make a lot of short kinks in the barrel that are very hard to get out. Gun barrel straighteners are the highest paid men we have. They get as much as $75 a week. You can see that our straightening expense is very low, but I have heard that companies using four-tool lathes have costs as high as 75 cents per barrel, so you can see that we are satisfied that our method is the best one, for us, at least."

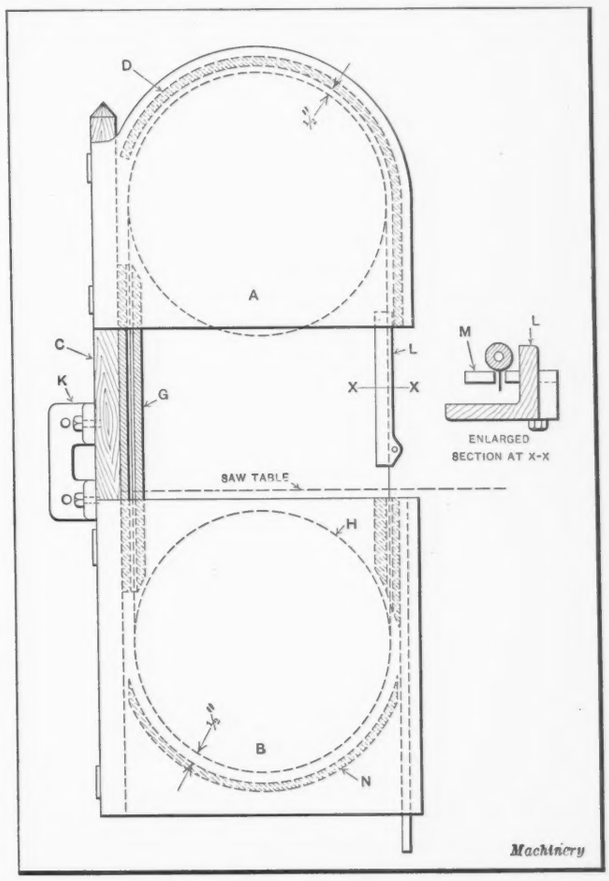
As I went out of the shop, I reflected that there are many things that even the well-informed efficiency engineer has never thought of.

Boston, Mass. L. L. THWING

BAND-SAW GUARD

It is said that a man who was once being examined for the position of state factory inspector, when asked the question, "What is the purpose of a guard on a band saw," replied as follows: "The purpose of a guard is a protection from injury," and continuing, added, "but more often kinked, bent, and broken saws, lower production, and a source of annoyance to the operator are the results."

Past experiences have caused the writer to form the same opinion of band-saw guards in general, especially those types in which little consideration has been given to the design from the standpoint of convenience to the operator. The design shown in the accompanying illustration is an all-wood guard, which has proved very satisfactory. No metal is



Improved Type of Band-saw Guard

used in the construction of this guard in places where it could possibly come in contact with the saw, either while in operation or in case the saw should break or slip off the wheels. It will be noticed that the saw is covered wherever possible, not only to protect the operator, but also to prevent it from becoming kinked, bent, or broken.

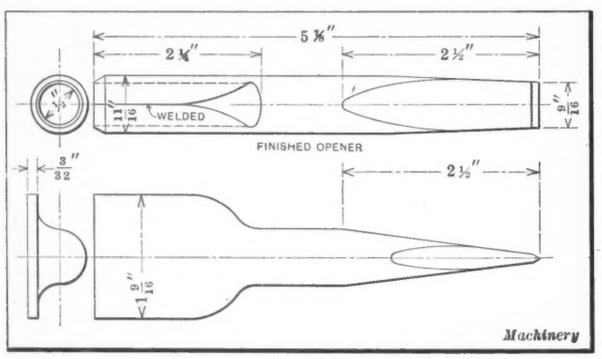
The guards *D*, *G*, *H*, and *N*, are of wood, guard *H* being so attached that it forms a chute for the sawdust when no dust collector is used. The wooden doors *A* and *B* are made from ¾-inch material and are hinged to post *C*. The complete guard is fastened in place on the machine by means of the bracket *K* to which the post *C* is attached by lag screws. The wooden piece *L*, a cross-section of which is shown in the enlarged sectional view, is fastened to the metal guide *M* in such a way that it is free to move vertically against the inside of door *A*. This permits guard *L* to be readily adjusted for work of various thicknesses. From the illustration it will be seen that when the doors *A* and *B* are opened there is nothing to obstruct the view or interfere with putting on, taking off, or adjusting the saw. To remove the guard it is only necessary to take out the two bolts in bracket *K*.

Kenosha, Wis. M. E. DUGGAN

SHOP AND DRAFTING-ROOM KINKS

COTTER-PIN OPENER

Workmen often cut or bruise their hands when trying to open or spread the ends of a cotter-pin after the pin has been driven into place. The accompanying illustration shows a device which has been designed to eliminate such discomforts, which are often experienced, especially when the cotter-pins are located in inaccessible places. In using this



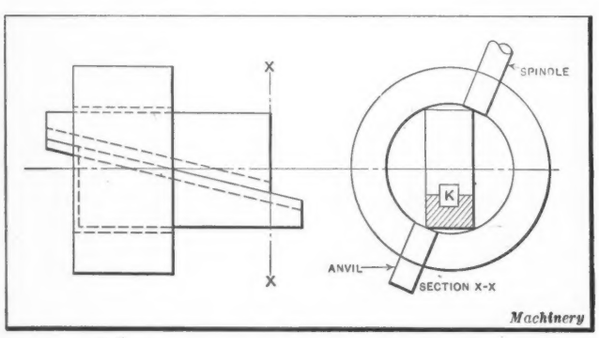
Tool for opening or spreading the Ends of Cotter-pins

tool the ends of the cotter-pin or key are separated by the chisel end of the tool and then bent over to the required angle by slipping the hollow cylindrical end of the tool over the projecting ends of the key. The tool is made from spring steel, the tubular end being produced by first flattening the end shown in the lower view and then forming and welding it to the shape shown in the upper view.

NORMAN MCCLEOD

MEASURING DIAMETERS OF HOLES

The measurement of straight holes or bores is usually attended by much variation in results and no little uncertainty as to the degree of accuracy. The use of an inside micrometer or the ordinary caliper and outside micrometer will not give results, as a rule, closer than 0.0005 inch. The method to be described in connection with the accompanying illustration will permit the measurement of internal diameters with a high degree of accuracy. The measurements are taken by means of an adjustable parallel and the use of an ordinary outside micrometer. The angle of the mating parts of the parallel is of no importance. The angular surfaces of both members as well as the key *K* should be ground and lapped, and the key slot in both members should be ground after hardening. In one half of the parallel this key should be a snug push fit, and in the other half it should be an easy running fit.



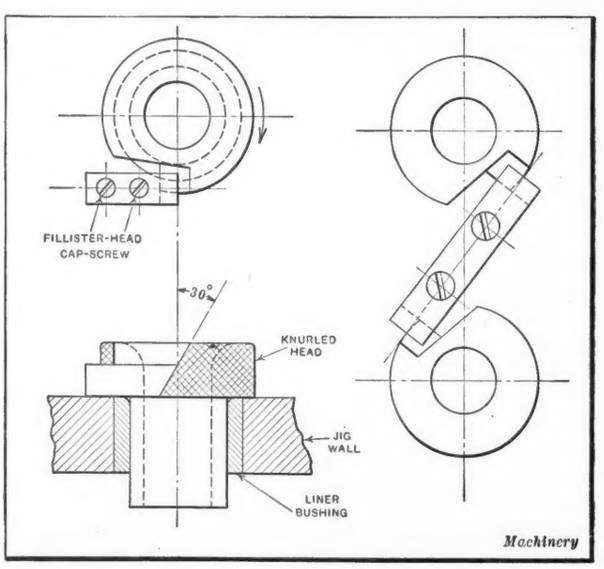
Method of using Adjustable Parallel when measuring Diameters of Bores

The assembled parallel must be ground all over, using a magnetic chuck or some other suitable holding device, and the four edges should be lapped to a slight radius, taking care that these edges are perfectly parallel throughout their entire length. The parallel is inserted into the hole to be measured and adjusted so that the edges touch the bore of the piece as illustrated, the measurement being taken over either pair of diagonally opposite edges. The degree of accuracy obtainable depends upon the skill of the mechanic using the micrometer, but should not produce a variation of over 0.0001 inch when measured by two different mechanics using the same micrometer. In lapping the edges to the slight radius it is understood, of course, that each pair of diagonally opposite edges should be lapped to exactly the same measurement. The use of this adjustable parallel will enable any slight taper in the hole to be easily detected, as such a condition will cause the parallel to rock or pivot when it contacts with that part of the bore which is tapered.

New Britain, Conn. WILLIAM C. BETZ

IMPROVED TYPE OF SLIP BUSHING

An improved type of slip bushing for drill jigs, which will stand the most severe usage, is shown in the illustration. The head of this bushing is milled off on one side to an angle of 30 degrees from the vertical. A hardened steel wedge made of square key stock, and having an angle of 30 degrees on one end, is screwed to the top of the jig by means of two



Arrangement for preventing Slip Bushings from working out of Place

fillister-head cap-screws, and in a position so that the two 30-degree surfaces will be parallel. When in use, the bushing will tend to rotate with the tool in the direction of the arrow, which will cause the bushing to wedge against the block and prevent it from revolving and consequently from working itself out of the jig. The right-hand side of this illustration shows the method of applying the slabbed slip bushing where the holes are close enough together to permit a single wedge block to be employed. F. W. S.

* * *

It is estimated that fifty of the leading automobile manufacturers employ altogether about 160,000 men in their factories.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

DIRECTION OF FEEDING MOVEMENT FOR THREAD-CUTTING TOOLS

G. E. J.—Should the inward feeding movement of a thread tool be at right angles to the axis of the work?

A.—It is preferable to set the compound rest at an angle of 30 degrees and feed the tool inward at this angle for each successive cut instead of at right angles to the axis of the work. When the tool is fed in at an angle of 30 degrees, one edge does practically all the cutting and the other edge moves parallel or opposite to the side of the thread; consequently the tool tends to tear the thread less and produces a smoother cut than when fed at right angles to the axis of the work. The tool may be moved straight in to take a light finishing cut after most of the metal has been removed by the angular feeding method.

HEAT-TREATMENT PROBLEM

ANSWERED BY S. P. ROCKWELL, SYRACUSE, N. Y.

The following information relative to the carburizing and casehardening of chain blocks is given in reply to the question submitted in the March number of MACHINERY, page 668. Although the question does not state just what trouble was experienced in carburizing the chain blocks, it is surmised that two troubles may exist: First, cracking of the work when hardening; second, breaking of the work after it has been assembled and placed under working strain. Nearly all trouble experienced in cracking while in the quenching bath is due to improper saturation. By this is meant not only the lack of uniform heating throughout the work, but also the degree of heat. Such an intricate part as a chain block demands that these factors be given special consideration. The casting should first be pack-annealed in charcoal or in a used carburizer, for a period of two or three hours at 1350 degrees F. This annealing process is required to remove the casting strains and to bring the grain structure to its normal condition.

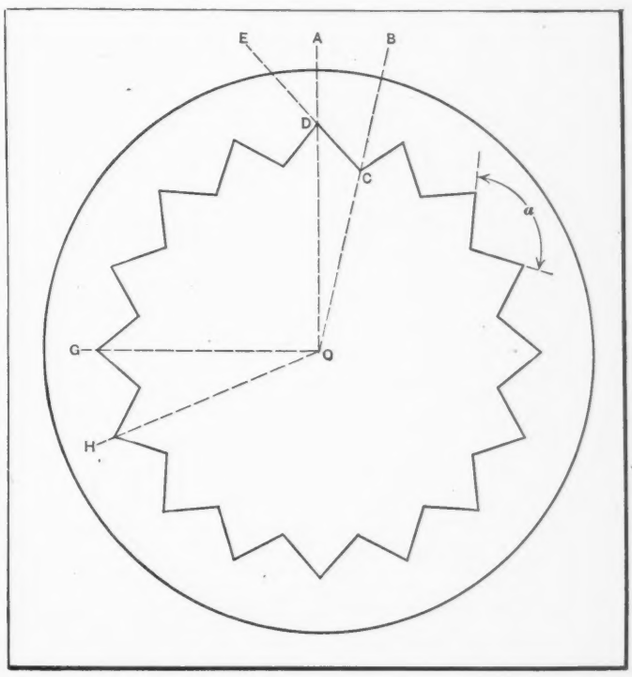
In carburizing, it is recommended that the cored surfaces be left soft and free from carburization, if this is possible. This may be accomplished by plugging the cored portions with clay or asbestos, or by painting with a viscous mixture of clay, water-glass, and white lead. It is advisable when carburizing to use a granular carburizing material of the air-regenerative type and to employ, as nearly as possible, a temperature of 1600 degrees F. The length of time required for carburizing cannot be intelligently stated, as the size of the carburizing pots etc., is not known. In order to determine when the required depth of carburization has been obtained, tell-tale rods thrust through the cover should be used, one of which should be occasionally removed, quenched, and broken so that the progress may be observed. The work should be allowed to cool while in the pot and then be reheated to a temperature of 1000 to 1625 degrees F., after which it should be quenched in oil.

The grain of the core in broken specimens should be as refined as possible, as any increase in the coarseness of grain indicates that the heat has been either too high or too low. The work should now be reheated to a temperature of 1475 degrees F. and quenched in oil. If, however, the surface hardness requirements are not obtained by quenching in oil, the work may be quenched in water when at a temperature of 1425 degrees F. The best condition will be indicated in the fracture by the finest case structure. The work should be drawn in oil using as high a degree of temperature as possible without danger of destroying the required degree of hardness. This temperature will be about 375 to 400 degrees F. By following this process, the highest physical qualities should be produced, and if proper saturation is obtained, no breakage when quenching should occur.

ANGLE OF TOOL FOR NOTCHING A RING

H. D.—The ring shown in the accompanying illustration is to have V-shaped teeth of a given angle a. What is the relation between this angle and the included angle of the tool used for cutting the notches, and how is the angle of the tool determined?

A.—Since the tool is to be shaped to cut out the notches between the teeth, the angle of the tool must be equal to the angle between the sides of any one of the notches. Draw the radial line OA, bisecting one of the notches, and the



radial line OB bisecting one of the teeth. Then, ECB equals one-half the angle of tooth, ODC equals one-half the angle of tool, and AOB equals one-half the center angle. By center angle is meant the angle between radial lines drawn from the center of the ring to corresponding points of two adjacent teeth, as, for example, angle GOH. By a principle of geometry, the exterior angle ECB of the triangle ODC equals the two opposite interior angles of the triangle. Hence,

$$\text{Angle } ECB = ODC + DOC, \text{ or}$$

$$\text{Angle } ODC = ECB - DOC$$

Multiplying by 2,

$$2 \times ODC = 2 \times (ECB - DOC), \text{ or}$$

$$\text{Angle of tool} = \text{angle of tooth} - \text{center angle} = \text{angle of tooth} - \frac{360}{\text{number of teeth}}$$

Example—What is the angle of the tool when the angle of the tooth equals 90 degrees and the ring is to have 60 teeth?

$$\text{Angle of tool} = 90 - \frac{360}{60} = 90 - 6 = 84 \text{ degrees}$$

NUMBERING DRAWINGS

J. W.—What is the best method of numbering drawings of jigs, tools, etc., and to what extent are symbols used to indicate classification?

A.—There is more or less difference of opinion regarding this matter and the exact method depends to some extent upon the conditions existing in various plants. In a plant building different types of machines, it is common practice to give each type a distinctive letter. For instance, "L" might represent lathe; "M," milling machine, etc. Following the letter, there is a number indicating the size of the machine. For instance, "L18" represents an 18-inch engine lathe. In order to identify the different parts of a machine, these parts are given serial numbers; thus, "L18-22" may represent the cone pulley of the lathe. This symbol would also be placed on the pattern in order to identify it.

Whether the part is made of steel or is a casting might be indicated by the size of the serial number. For instance, all castings might have numbers below 500, and all steel parts, numbers above 500. This idea has been carried a step further in some plants, especially where a single product is manufactured. For instance, one concern which manufactures an adding typewriter uses letters to indicate general sections of the typewriter or adding mechanism, and the number shows whether the part is a shaft, screw, collar, drop-forging, casting, punched part, spring, or a miscellaneous piece not belonging to the more common classes referred to. If "A" represents the accumulator mechanism, and if all parts between 10 and 29 represent some kind of stud, pin, or screw, the symbol for a screw of the accumulator mechanism would be composed of the letter "A" followed by some number between 10 and 29. This symbol is marked on the drawing and on any special tool that might be required.

A method commonly employed in numbering tool drawings, is to give each tool a serial number and combine this number with symbols representing the part the tool is used for and the machine to which the part belongs. For instance, if "L18-22" represents the cone pulley of an 18-inch engine lathe, the symbol "L18-22-55" might represent a special reamer used for this cone pulley.

CASEHARDENING STEEL

J. M. E.—What general equipment is required in casehardening machine steel with cyanide to obtain the bright colors usually found on firearms? What grade of machine steel is generally used? From whom can cyanide be obtained, and what is its present cost? Is cyanide explosive and, if so, under what conditions?

ANSWERED BY S. P. ROCKWELL, SYRACUSE, N. Y.

The use of cyanide to produce variegated colors on hardened steel is a simple process. The work is immersed in the bath, brought up to its hardening temperature, and then transferred to a water bath for quenching. While in the cyanide bath the steel is protected from the oxidizing effect of the air and it is also protected during its transfer to the quenching bath by a liquid film of cyanide which adheres to the steel and thus prevents the air from coming in contact with the work.

At the moment of quenching, the cyanide causes the quenching bath to become violently agitated as a result of the rapid transformation of small quantities of water to steam; this steam and the air drawn into the water by this agitation, partially oxidizes the steel in spots, giving the variegated colors, which are simply intensified tempering colors. The use of a cyanide pot for complete immersion of the work is more satisfactory than the method of sprinkling powdered cyanide on the work while it is being heated. Fair results can often be secured by the latter method, but more often the cyanide burns off and the steel is oxidized beyond the temper colors of, say, 650 degrees F. To increase the mosaic effect and obtain brighter colors, hardeners effectively employ either or both of the following methods: (1) Pass the hot steel through a water spray when transferring from the cyanide to the quenching bath. (2) Have a stream of air bubbling through the water in the quenching tank.

If the quenched work is removed from the quenching bath while warm and rubbed with oil, the colors will be brought out more perfectly. In order to obtain the best color results the steel should have a good initial polish. Blemishes such as rust, oxidation, finger prints, greases, etc., are liable to destroy perfect results. Cyanide furnaces are produced by a large number of furnace-makers and may be obtained at prices ranging from $100 to $500, depending upon the size of the furnace. However, furnaces which are suitable for this work can be constructed by the user for about one-half the cost of the commercial types. Cast-steel pots are, as a rule, most satisfactory and can be secured in standard patterns for twelve cents per pound.

Firearm manufacturers do not depend on cyanide alone for their color effects. They often desire a deeper hardening effect than can possibly be obtained with cyanide, and to meet such requirements they pack the cleaned steel in bone, charcoal, leather, or a combination of these materials. A small percentage of cyanide salts is added in some cases. Regular carburizing boxes are used as containers. These boxes are charged into a furnace maintained at 1400 to 1550 degrees F., and held there until the work has been carburized to the required depth. The boxes and contents are then brought close to the surface of the water in the quenching tank which usually has air bubbling up through it. From this position the pot is turned upside down, the steel falls into a screen basket in the tank and the packing material falls to the bottom from where it is later removed. Any steel will color if properly treated. The following gives the analysis of the steels commonly employed by gun-makers:

	Carbon, Per Cent	Manganese, Per Cent	Silicon, Per Cent	Sulphur, Per Cent	Phosphorus, Per Cent
Screw Stock ..	0.10-0.30	0.30-0.70	0.02-0.15	0.08	0.12
Gun Steel	0.15-0.25	0.50-0.90	0.02-0.15	0.06	0.06
C Steel	0.30-0.40	0.70-1.00	0.06-0.10	0.04	0.04
A Steel	0.45-0.55	0.45-0.75	0.15-0.25	0.04	0.035
Lock Steel	0.70-0.90	0.30-0.80	0.05-0.20	0.035	0.035
B Steel	0.95-1.10	0.25-0.40	0.15-0.20	0.019	0.022

The second, third, and fourth steels are forging steels; the fifth is used for parts which must be very hard and which must be subjected to shock; and the sixth is used for springs. The grade of steel used, of course, depends on the amount of strain, torsion, or shock which the finished article must withstand.

Cyanogen gas for commercial use is compounded with salts, the most common salts being those of sodium or potassium. Sodium cyanide has been used extensively during and since the war, as potassium cyanide could be secured only with difficulty. Sodium cyanide, however, can be procured from the Solvay Process Co., the Grasselli Chemical Co., or almost any chemical supply house. There are on the market a number of patent preparations supposed to be non-poisonous. These are, as a rule, simply diluted cyanide compounds. The diluted salts may be sodium chloride, potassium chloride, or barium chloride. These compounds give off less harmful gases but, on the other hand, do not ordinarily produce as good results in hardening or give the bright colors obtained by the use of commercial sodium or potassium cyanide. The former may be purchased in 100-pound lots for about 27 cents per pound at the present time.

Cyanide is not explosive. The contents of a cyanide pot will often be thrown out suddenly, due to water being forced beneath the surface by wet tongs or work. The steam which is suddenly evolved expands so rapidly that it throws out the cyanide. This will happen with any salt and with molten lead. Oil, however, will not have this effect, and for this reason it is usually best to dip the tongs or work into oil after having had them in water, or before immersing them in the cyanide.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

National Acme Three- and Four-Inch Multiple Automatics. National Acme Co., Cleveland, Ohio..... 771
Ryerson-Conradson Radial Drilling Machine. Joseph T. Ryerson & Son, 16th and Rockwell Sts., Chicago, Ill..... 774
Betts-Bridgeford Geared-head Lathe. Betts Machine Co., Rochester, N. Y..... 775
Machine Products Co.'s Gear Quenching Machine. Machine Products Co., E. 179th St. and St. Clair Ave., Cleveland, Ohio..... 775
Hunter Improved Tooth Adjustment for Inserted-tooth Saw Blades. Hunter Saw & Machine Co., Pittsburg, Pa..... 776
Detroit Hexagon Drills. Detroit Hexagon Drill Co., 27-29 Woodward Ave., Detroit, Mich..... 776
Genesee Facing Tool. Genesee Mfg. Co., Rochester, N. Y.... 777
"Sterling" Saw for Motor Truck Tires and Rims. Diamond Saw & Stamping Works, 357-361 Seventh St., Buffalo, N. Y..... 777
Mummert-Dixon Radial Grinder. Mummert-Dixon Co., Hanover, Pa..... 777
Grand Rapids Tap Grinding Machine. Grand Rapids Grinding Machine Co., 29 Ottawa Ave. N. W., Grand Rapids, Mich..... 778
Atlas Arbor Presses. Atlas Press Co., 323 N. Park St., Kalamazoo, Mich..... 778
Peerless "Duplex" Hacksaw Blades. Peerless Machine Co., 1611 Racine St., Racine, Wis..... 779
O. R. Adams "Short Cut" Lathe. O. R. Adams Mfg. Co., Inc., Norton St., Rochester, N. Y..... 779
Lapointe Machine Tool Co.'s Duplex Broaching Machine. Lapointe Machine Tool Co., Hudson, Mass..... 780
Quick-action Drill Chuck. Superior Collet Chuck Co., Grand Rapids, Mich..... 780
Ryerson-Glader Wire Nail Machine. Joseph T. Ryerson & Son, 16th and Rockwell Sts., Chicago, Ill..... 781
Efficiency Pipe Wrench. Efficiency Device Corporation, 203 8th St., Long Island City, N. Y..... 781
Sebastian Engine Lathe. Sebastian Lathe Co., 154 Culvert St., Cincinnati, Ohio..... 782
Badger Grinding Machine. Badger Tool Co., Beloit, Wis.... 782
United Power Hammer for Pulverizing Pig Iron. United Hammer Co., Oliver Bldg., Boston, Mass..... 782
Greenfield Universal Grinding Machine. Greenfield Machine Co., Greenfield, Mass..... 782
Streine Forming and Roofing Press. Streine Tool & Mfg. Co., New Bremen, Ohio..... 783
Bicknell-Thomas Tapping Machine. Bicknell-Thomas Co., Greenfield, Mass..... 783
GTD Limit Screw Pitch Gage. Greenfield Tap & Die Corporation, Greenfield, Mass..... 784
Gammons-Holman Taper Pin Hole Reamer. Gammons-Holman Co., Manchester, Conn..... 784
Victor Collapsible Tap. Victor Tool Co., Inc., Waynesboro, Pa..... 784

National Acme Multiple Automatics

These 3- and 4-inch automatic screw machines have been designed along lines which provide for applying to the production of large sized work, the principle of completing all operations in the time of the longest cut. Although the general features of this company's previous machines have been retained in the design, many details were modified to provide for contingencies incident to the construction of larger machines; and to incorporate in an equipment of this size such features as convenience of operation, reduction of the consumption of power to a minimum, the application of safety devices, the simplification of design, and standardization of auxiliary apparatus.

TO meet the requirements of metal-working plants which manufacture parts that could be advantageously produced from bar stock on automatic screw machines, the National Acme Co., Cleveland, Ohio, has recently added to its line an "automatic" which is built in 3- and 4-inch sizes. This machine utilizes the multiple-spindle principle of construction which is familiar to the trade in machines of smaller capacity, and makes it possible to save time through completing all operations in the time of the longest cut. Aside from the necessity of providing increased strength incident to the construction of a larger sized machine, it was necessary for the designers to make a number of departures from the previous lines of construction followed by this company. Among these features of design attention is called to the standardization of auxiliary equipment for use on the machine, care which has been taken to assure convenience of operation, precautions taken to reduce the consumption

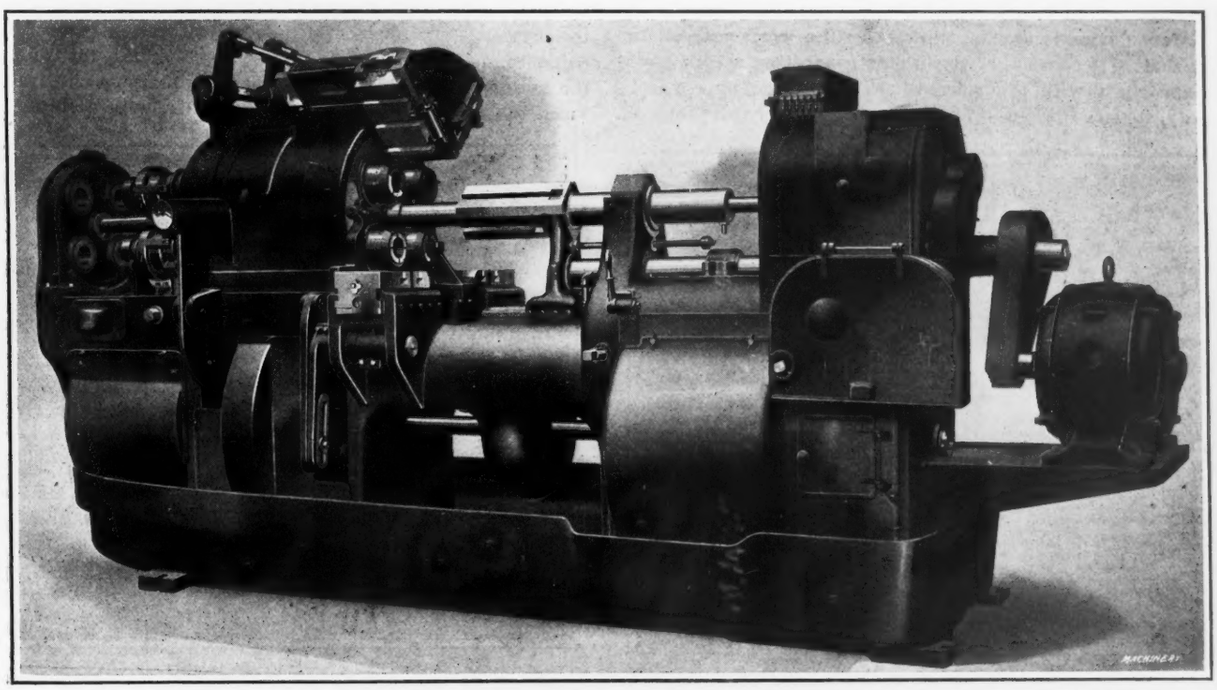


Fig. 1. General View of the National Acme Multiple-spindle Automatic Screw Machine which is built in 3- and 4-inch Capacities

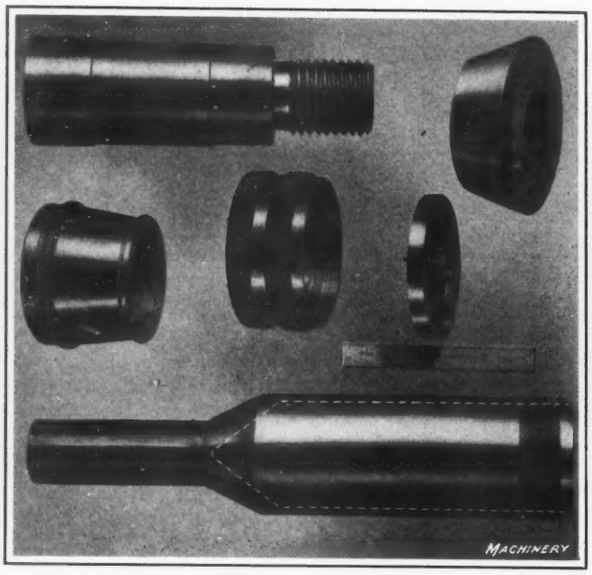


Fig. 2. Examples of Typical Work produced on National Acme Screw Machines of the Type shown in Fig. 1

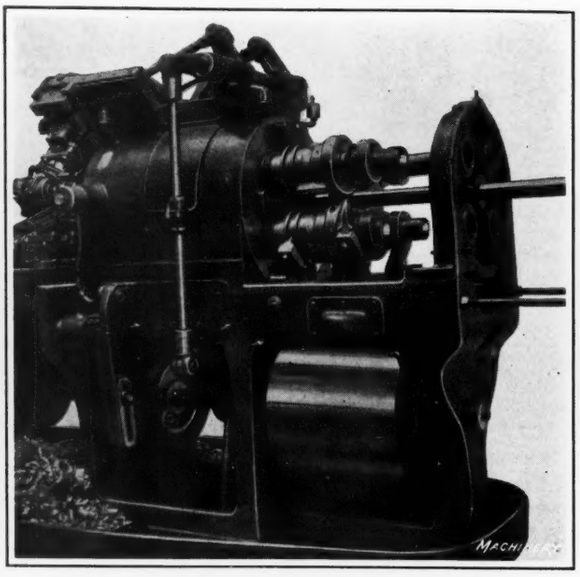


Fig. 3. Stock may be fed in either the First or Fourth Spindle Position by making a Simple Adjustment

of power as far as possible, the application of safety devices, and the simplification of design.

Noteworthy Features of Design

Attention is called to the following noteworthy details of design and construction: The pan is of unusual size and made with three strong ribs in the floor portion. Ample chip space is afforded by the open construction below the main tool turret; and the oval form of the center bed allows the chips to be quickly washed off into the pan. By placing the side operating mechanisms, forming tools, and cut-off under the cylinder, the chips are kept away from the working parts. All tools on the main tool-carrier are placed inside the circumference of the spindles, thereby providing for the use of tools of various sizes and shapes without interfering with each other or with the center turret extension. The tooling is placed at a convenient height for the operator, which greatly facilitates setting up or making adjustments. Lubricant is delivered to the tools through feed-pumps and tubing of ample size to provide a copious flow to each tool.

All gears, cams, drums, etc., are completely covered, and a safety device is applied directly to the worm-gear on the camshaft. It consists of shear pins connecting a disk keyed to the shaft with the worm-wheel, and these pins can be easily replaced when broken. Such a device prevents accidents resulting from improper timing due to errors in setting up the tools, or carelessness in operation. The starting clutch lever for the automatic feed is controlled from either side, and when thrown into the automatic feed, the hand crank is mechanically disengaged, thus avoiding any possibility of accidents. The main tool-carrier cams are supplied in accordance with the requirements of the work. The top slides are controlled by one cam on the main shaft and straight interchangeable cams placed directly behind the top slides. Both the 3- and 4-inch machines may be equipped for either belt or individual motor drive.

Main Tool-slide

Provision is made in the design of the end tool turret for rigidly supporting the tools as well as making them readily accessible while setting up. One end of the steel casting from which this part is made extends beyond the four-faced turret and enters a bearing at the center of the cylinder. The rear end is supported in a heavy bearing through an upright extension of the frame, which is cast integral with the bed. It is supported just back of the tools by an extension of the pusher-rod which controls the feed of the tool-carrier. This pusher is independent of the tool-carrier, being connected to the carrier by a pin at the top, and at the bottom it travels on a wide bearing plate on the frame. From the pusher-rod there is an extension with a roller for

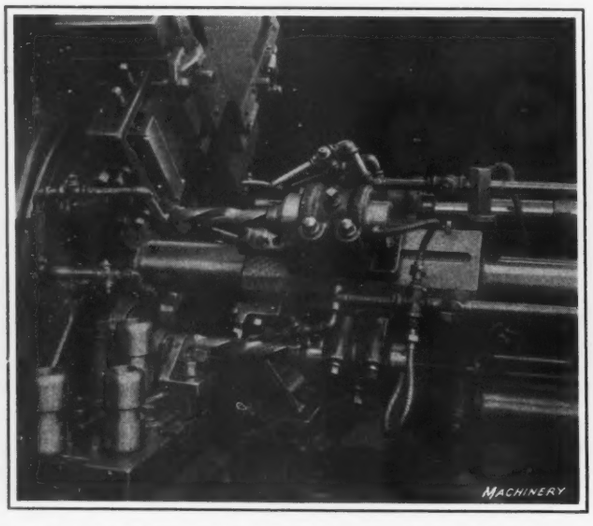


Fig. 4. Heavy-duty Drilling Operation with Oil-tube Drills, showing how the Tools are held on a Wide Bearing Surface of the Carrier

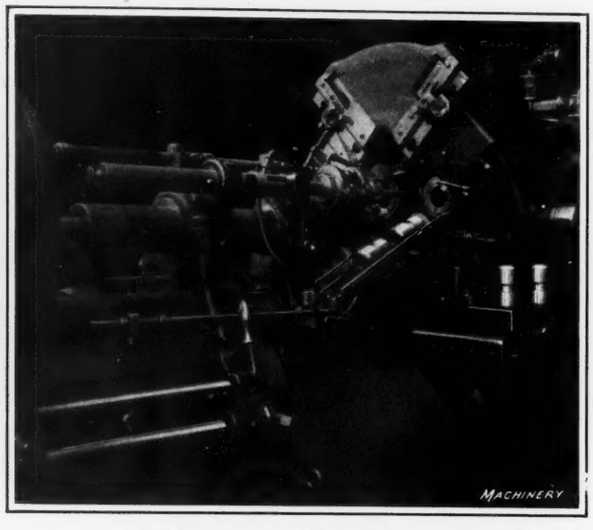


Fig. 5. Application of the Accelerated Reamer Attachment and Carriers for Heavy Work. This View also shows Top Slides

the lead cam, this extension being fastened to the pusher-rod which is supported at a 45-degree angle with respect to the lead cam, and its movement is against a hardened steel plate secured to the bed. The bearings receive no side thrust from the lead and take-back cams. This system of supporting the tool-carrier equalizes side thrust, so that heavy cuts and coarse feeds may be employed without affecting the accuracy of the product. The stop-rod between the pusher and the carrier is the main stop for accurately regulating the length of turret travel. This is controlled by nuts adjusted for different lead cams. Tool-holders with wide bearings are fastened against the four flat faces of the turret, and are supported directly beneath their cutting points with no overhang.

Arrangement of the Forming and Cut-off Slides

Both the forming and cut-off slide bearings are cast integral with the bed and designed to support the forming tool over its entire length and directly beneath the cutting pressure. Connection between the forming and cut-off levers and their slides is through a 2½-inch hexagonal shaft, which assures a positive feed to the slides without any tendency to spring. The slides are adjusted vertically by tapered gibs, and horizontally by straight gibs. Levers which control the feed of the cross-slides are furnished with slots, making them easily adjustable and requiring only a minimum change of cams for different feeds. Three cams are

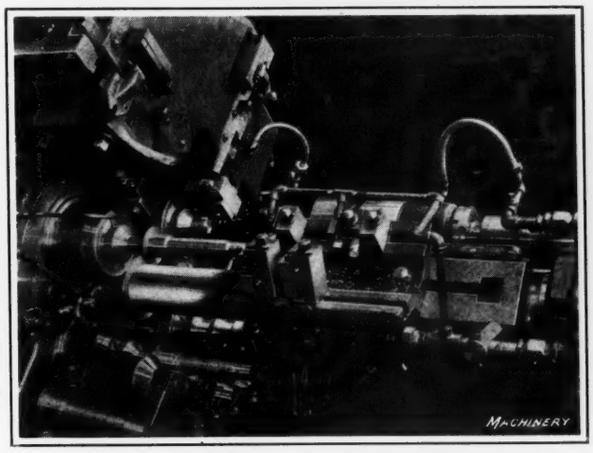


Fig. 6. A Typical Set-up of Turning Tools; in this Illustration are also shown the Top Slides and Provision for forming

sufficient to cover all requirements. A forming stop, which consists of a bracket mounted on the slide in connection with adjustable studs located between each of the four spindles, provides a separate adjustment for each and constitutes an additional safeguard for the uniformity of the product. To facilitate quick, accurate adjustment for the depth of cut for the forming and cut-off tools, the screws are operated through the center of the slides independently of the tool-holders.

Construction of the Cylinder

In working out the cylinder design, features have been developed which are claimed to minimize wear and facilitate the making of adjustments. The cylinder casing has been made unusually strong, and in addition to being secured to the bed by heavy bolts, it is dovetailed to the bed. Two brass shoes are located independently on top of the cylinder casing, for both front and rear bushings, and they are adjusted by screws without any interference with the top slide. It should be borne in mind that this adjustment is made toward the center of the machine where the greatest strain is experienced. Compensation for end wear is accomplished by a take-up located on the rear of the cylinder and secured by adjustable brass shoes on the reel cross support and tightened to the cylinder. However, the cylinder does not depend wholly upon its bearing against the adjustable shoes to resist the end thrust, because the front of the cylinder is counterbored thus giving the bearing its entire periphery in the cylinder casing.

Design of the Spindles and Bearings

Both the front and rear spindle bearings are of the straight type, the material used being a special bronze composition, with end thrust bearings. Attention is called to the fact that the spindles are not affected by wear, because main bronze bearings are secured to the spindles and run in hardened steel bushings fitted to the cylinder. Moreover, the spindle gears are located centrally between the bearings instead of at the ends of the spindles, so that the pressure of the gears tends to equalize the action against the bearings on the spindles, at the same time affording rigid support by reason of the bearings being located further apart. The result of this construction is an easy rotative action, lower power consumption, higher speed, and easy replacement of both the spindle and cylinder bearings when they become worn.

Threading Spindle Mechanism

These Acme 3- and 4-inch automatics are not ordinarily equipped with a threading spindle, but provision is made for including it as part of the equipment. The die spindle is operated independently of the travel of the main tool-carrier, and is rotated at a speed slightly less than that of the stock spindles while the thread is being cut, but after-

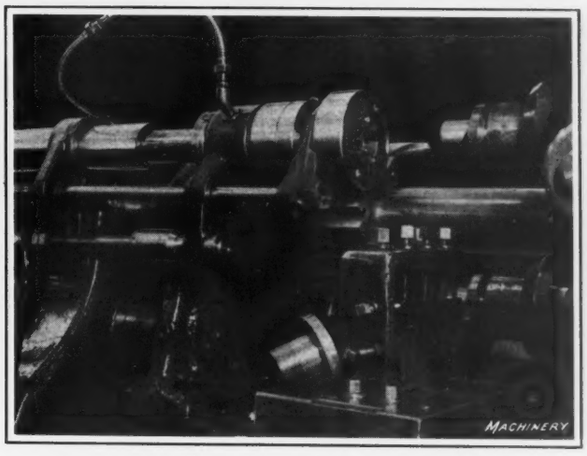


Fig. 7. Application of a "Namco" Self-opening Die on the National Acme Screw Machine for performing a Threading Operation

ward at a higher speed to run the die off the work. There are two cutting and two return speeds. A double gear is used to afford these two changes. Spindle speeds are varied by changing the double gears; and changes from left-hand to right-hand threads are accomplished merely by reversing the cams operating the friction. When button dies or taps are used, an extra holder is employed; but for opening dies or collapsing taps, only the regular equipment is required. No arrangement is made for stopping the die spindle to permit using special operation fixtures, as on smaller machines of this company's manufacture.

The Quick Turn-over

The turn-over of the stock-carrying cylinder is accomplished by a Geneva movement, which is quick and positive in operation and exerts a minimum strain on the parts. Locking of the cylinder in its four successive positions is done by a latch bolt on the forming side of the cylinder and a locking bolt on the cut-off side. This arrangement has been found most practicable, because the locking bolt naturally pulls the cylinder down, and with this system there is less competing pressure. Positive operation of the locking bolt is controlled by a spring directly in connection with the bolt, and by a cam and roller from the main camshaft, which affords a rigid locking action when heavy or exceptionally long bars are being machined.

Arrangement of the Top Slides

Operation of the top slides is accomplished by two straight and interchangeable cams, from which movement is transmitted through rods and levers arranged so that both slides can be adjusted by manipulating one interchangeable cam on the main camshaft. The top slides accommodate the same holders and tools that are used on the forming and cut-off slides, and the method of adjusting these slides by gibs is the same.

Stock Feed

Stock may be fed in either the first or fourth spindle position, according to the class of work in hand. The wedge levers for opening and closing the first and fourth position tubes are readapted merely by reversing the brass shoes. Movement of the stock stop is changed simply by shifting the cam-lever 30 degrees on the square end of the hexagonal shaft, and moving the cam backward to give the proper throw. The slide controlling the stock feed is independent, having its bearing on two rods between the casing and the

Arrangement of the Head

The head is mounted on S K F ball bearings and travels on the top surface of the arm, where it is held in place by a plate guided by parallel vees on the under side of the arm. This plate serves various purposes, chief of which is to keep the head in perfect alignment with the arm. Cross traverse of the head is facilitated by having it carried on ball bearing rollers provided with eccentric shafts which furnish means of adjusting to compensate for wear. A reversible motor is mounted on the head and directly connected to the driving shaft by means of a self-aligning internally splined coupling. This driving shaft carries a pinion and gear, the pinion being cut integral with the shaft, and both run in mesh at all times with clutch gears of the conical friction type. The friction cones are mounted on a spacing rod and a movement up or down from the neutral position engages the high- or low-speed clutch gear. Four other gears are keyed to this clutch shaft and drive the spindle sleeve over change-gears on an auxiliary shaft.

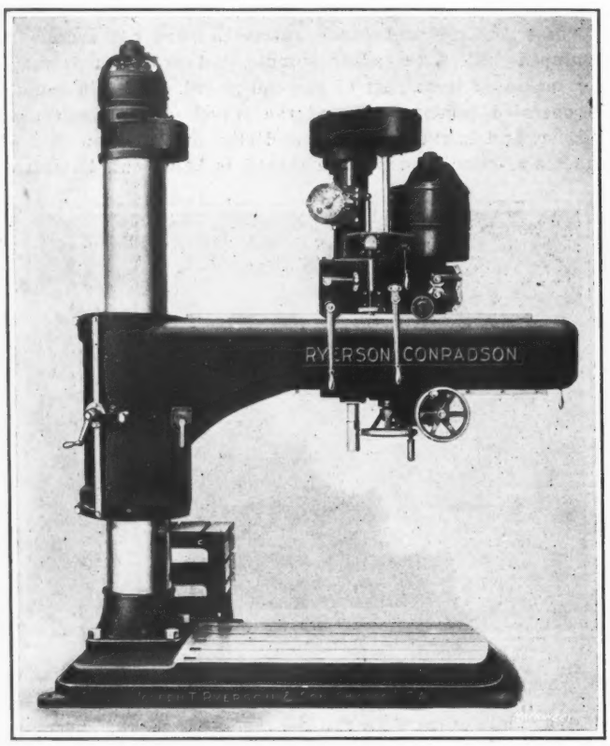


Fig. 1. Radial Drilling Machine built by the Conradson Machine Tool Co., for which Joseph T. Ryerson & Son have the Exclusive Sales Agency

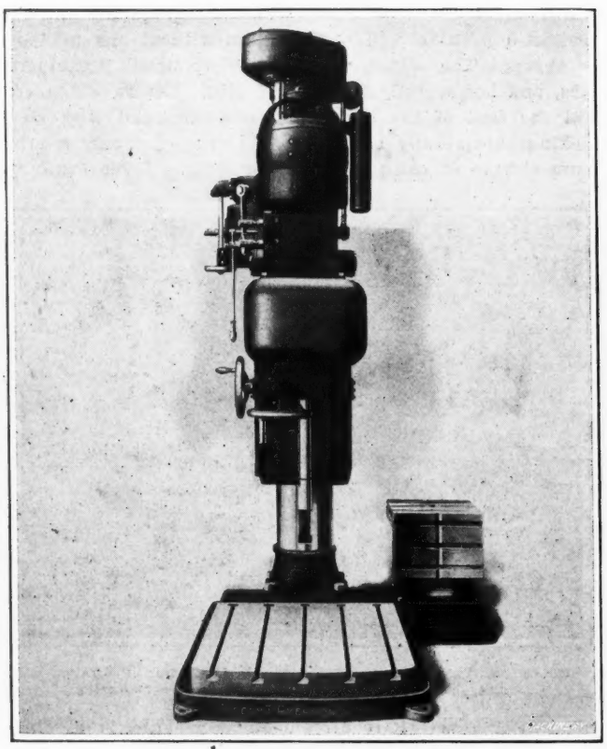


Fig. 2. End View of Ryerson-Conradson Radial Drilling Machine, illustrated in Fig. 1, showing Extension of Base and Box Table

end of the machine. It is equipped with double levers connected by rollers, and one of these rollers is changed in two positions for the 6-inch and 12-inch feeds. Intermediate rates of feed are secured simply by adjusting the collar on the stock pusher-rod.

RYERSON-CONRADSON RADIAL DRILLING MACHINE

Reference to the accompanying illustrations will make it apparent that in working out the design of a radial drilling machine which has recently been placed on the market by the Conradson Machine Tool Co., Green Bay, Wis., a marked departure has been made from established lines followed in the construction of this type of machine tool. This is a twin motor-driven, high-power machine, and it is stated that drilling, tapping, boring, and reaming operations can be performed on it with an equal degree of efficiency. Attention is called to the simplicity of the mechanism, there being only four shafts and sixteen gears.

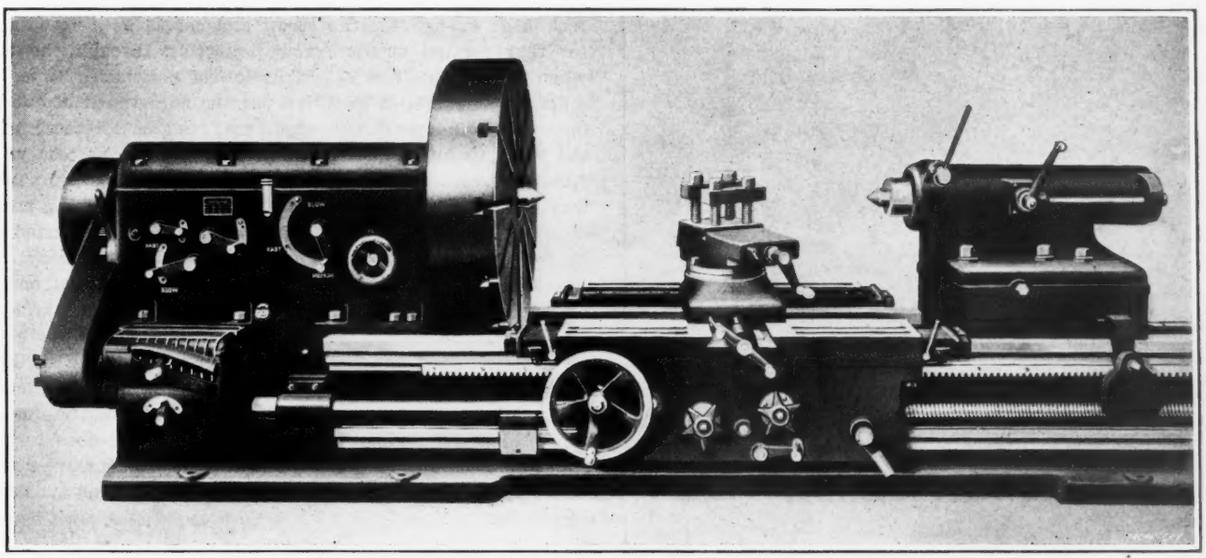
The auxiliary shaft is splined and the change-gears are shifted by two yokes which are actuated by interlocking levers, making it impossible to engage two sets of gears at the same time. Each end of the auxiliary shaft carries a pinion which is permanently in mesh with a bronze-bushed gear on the spindle sleeve. A jaw clutch engages one or the other and effects the drive. The spindle has two keyways cut over its entire length and is driven by two inserted keys in the sleeve. By shifting the levers, all of which are on the head, the operator engages the desired speeds. Sixteen speed changes are available, covering a range from 19 to 310 revolutions per minute, and arranged in geometrical progression. For tapping, the motor is reversed, this action being instantaneous and entirely without shock. The head is completely enclosed and all gears run in oil, a gage keeping the operator informed as to the oil level. All shafts run in S K F ball bearings.

Arrangement of the Feed and Elevating Mechanisms

Two series of eight feeds each are provided on this machine, covering a range of from 0.005 to 0.078 inch and from

0.023 to 0.370 inch per revolution, each series of changes being in practically geometrical progression. These changes of feed are secured by a cone of gears engaged by a driving key that is controlled by a feed indicating dial, and also by engaging in the upper or lower position a clutch controlled by a lever on the handwheel. All feeds are instantly disengaged by a friction clutch on the handwheel shaft, which is actuated by a lever conveniently located on the head. By the use of an automatic or adjustable stop, the feed is disengaged when the desired depth is reached. For raising and lowering the arm, an independent motor is mounted at the top of the column. A pinion is keyed directly to the armature shaft and drives a reducing gear on the elevating screw, the thrust of which is taken up by a ball bearing. This composes the entire elevating mechanism, and limit switches are provided to control the movement, these switches being equipped with a bracket carrying a roller that opens the circuit when struck by the sleeve of the arm. The arm revolves on ball bearings and is carried by a sleeve of exceptional length to which the elevating nut is attached.

Means are provided for clamping the arm securely to the column with equal pressure at the top and bottom. A pneumatic clamping device can be furnished if desired. The center of the spindle is arranged to travel on a radial line passing through the center of the column which is a hollow cast-iron cylinder bolted to the base. Surrounding the base there is a deep flange which serves the double purpose of stiffening the construction and serving as an oil retainer. Both the main driving and elevating motors are of the reversing type, and if the machine is ordered with complete electrical equipment, these motors are furnished to order. They are operated by a control apparatus consisting of reversing contactors, auxiliary units, two knife switches properly mounted in a steel cabinet, and two master control switches for any desired standard current or voltage. Radial drilling machines of this type are built in 4-, 5-, and 6-foot sizes. Joseph T. Ryerson & Son, 16th and Rockwell Sts., Chicago, Ill., have the exclusive sales agency for these machines.



Geared-head Lathe built in Swings from 32 to 48 Inches by the Betts Machine Co.

BETTS-BRIDGEFORD GEARED-HEAD LATHE

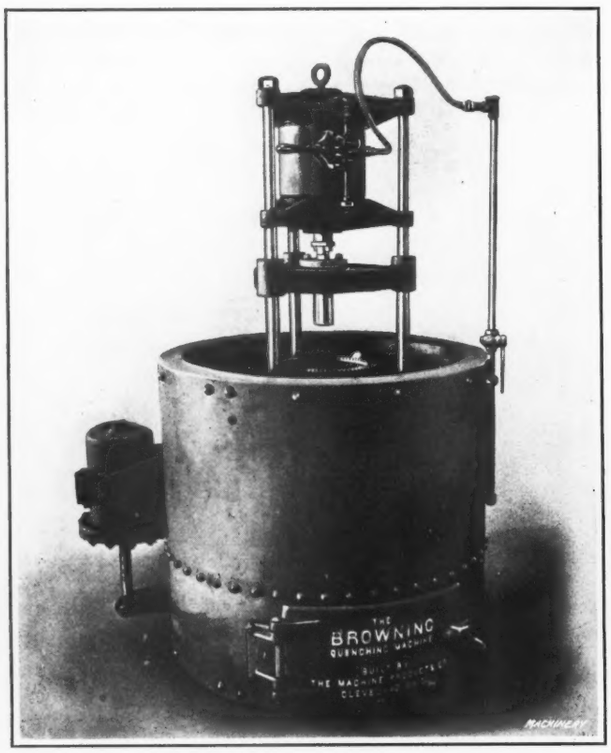
A new type of geared lathe head has been designed by the Betts Machine Co., Rochester, N. Y., and applied to the full line of heavy-duty engine lathes built by this firm in swings from 32 to 48 inches. This headstock is fully enclosed and operated by a powerful expanding ring friction clutch upon which the driving pulley is mounted. Provision is made for operating the clutch from the apron so that its control is always convenient for the operator. A single movement disengages the clutch and automatically applies a friction brake, thereby stopping the machine almost instantly. Nine changes of spindle speed are provided, three changes being obtained by direct drive, while two modifications of each of these speeds are secured through the gearing. These changes are instantly obtained and controlled by three conveniently located levers mounted at the front of the headstock. All speed changes are in geometrical progression and are secured through hardened steel gears and positive clutches running in oil, the edges of the gear teeth being rounded to provide for instant and easy engagement. There are twelve gears in the headstock, including the faceplate pinion and gear. An interlocking device is provided so that no two speeds can be engaged at the same time. Easy access to all of the parts is accomplished by having all of the shafts and gears located in the lower half or base of the headstock, so that the cover can be easily removed to make all of the mechanism accessible. All shaft bearings are bronze bushed, and lubricant is supplied to the bearings by a pump located in the headstock, which distributes oil to all of the bearings eliminating the possibility of any bearing running dry, it being merely necessary to keep the oil at the designated height. When the machine is motor-driven, the motor is mounted on top of the headstock cover and directly connected through gearing to the main driving shaft.

MACHINE PRODUCTS CO.'S GEAR QUENCHING MACHINE

To prevent gear blanks from warping while they are being hardened, the Machine Products Co., E. 179th St. and St. Clair Ave., Cleveland, Ohio, has developed the Browning quenching machine which is here illustrated and described. This apparatus consists of a cylindrical shaped tank in which a plate is secured about one-third of the way up from the bottom, the periphery of this plate being flanged upward and securely riveted to the cylindrical wall, with the seam calked to make it liquid-tight. The upper portion of the tank is filled with any quenching fluid such as water, brine, or oil; and the usual cooling and circulating system keeps the fluid at the desired temperature. At the center of the diaphragm plate there is fastened a casting furnished with three bearings for guiding the die-plates and clamping cylinder, with a bearing and stuffing-box through which a rod passes by means of which submerging of the work is accomplished. This rod is guided in such a way that it always travels in

a straight line, and it is connected at the lower end to a lever supported at the center by a rocking fulcrum, and at the opposite end to the piston-rod of the submerging cylinder.

Ready access to the stuffing-box and mechanism below the diaphragm is obtainable through a large door at the side of the tank. The submerging cylinder is 8 inches in diameter, and it has a stroke of 8 inches, the cylinder being supported by a trunnion casting fastened to the outside of the tank, and the air is supplied through one of the trunnions by a swivel joint which allows the cylinder to adjust itself to any necessary position. Two heads are clamped to opposite ends of the clamping cylinder by means of three long bolts which extend beyond the lower head and through the die-castings, thus furnishing a guide for the movable one and tie-rods for the fixed one, these bolts extending far enough to furnish guides for the whole outfit while being submerged.

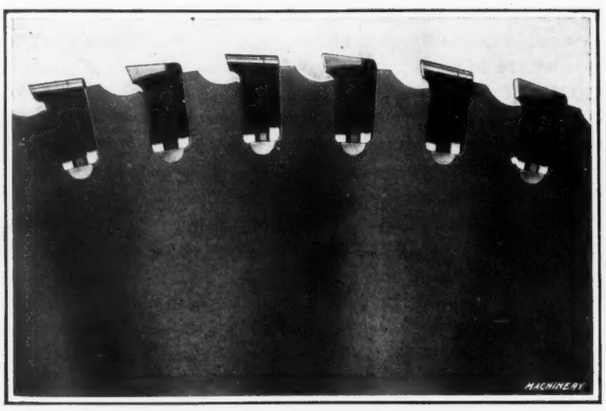


Browning Gear Quenching Machine built by the Machine Products Co.

Radial slots are provided in the dies for fastening the work to them, and also for allowing the quenching fluid to quickly reach all parts of the gear blank. The upper die-plate is movable and is fastened to the piston-rod of the clamping cylinder. A valve governs the operation, and it is conveniently located for the attendant. In its first position, this valve applies air to the submerging cylinder and raises the dies out of the quenching fluid; in the second position, it admits air to the clamping cylinder and raises the upper die; in the third position, it exhausts air from one end of the clamping cylinder and by applying air to the other it securely clamps the dies on the work; and in the fourth position, the valve exhausts air from the submerging cylinder and allows the dies and work to drop into the quenching fluid. This machine is entirely self-contained and requires no special foundation.

HUNTER IMPROVED TOOTH ADJUSTMENT FOR INSERTED-TOOTH SAW BLADES

A new arrangement for adjusting the teeth of inserted-tooth saw blades to the proper distance from the center has recently been developed by the Hunter Saw & Machine Co., Pittsburg, Pa. The high-speed steel teeth are supported by hex-head heat-treated steel screws and one-half round removable steel nuts embedded in the body of the saw blade. A milled tongue in the semicircular nut pocket, fitted into a groove in the nut, holds it firmly in place and prevents any side movement. The clearance hole drilled into the body of the saw blade at the bottom of each nut pocket is made just large enough for the screw and serves as a receptacle for that portion of the screw projecting through the nut when the saw tooth is set in its lowest position.



Improved Type of Tooth Adjustment used on Inserted-tooth Saw Blades made by the Hunter Saw & Machine Co.

An arrangement of this kind permits adjustment of one or more teeth independently of others; and as all teeth will not wear to an equal degree, it may become necessary at times to remove one or more teeth for regrinding. This may also be necessitated through breaking the cutting point of a tooth. In either case, the tooth must be readjusted to its proper relative position with other teeth carried by the saw blade. The screws and nuts are easily removed or replaced, if either should become damaged or worn through service. After setting to the proper height, the tooth is securely clamped in position by a grooved wedge or key made of hardened steel. It will be seen that alternate teeth of the saw blade have round and square noses, the round teeth being set slightly higher than the square ones to act as leaders. The bodies of these Hunter saw blades are made of tough, heat-treated steel to resist the most severe classes of service.

DETROIT HEXAGON DRILLS

For use in cutting square and hexagonal shaped holes, the Detroit Hexagon Drill Co., 27-29 Woodward Ave., Detroit, Mich., is making a line of tools, two types of which

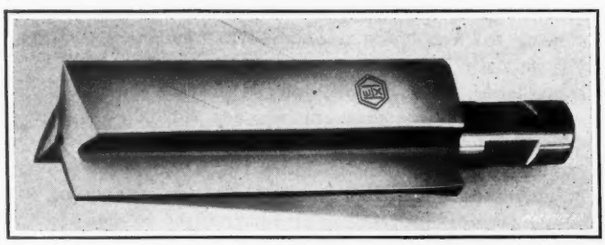


Fig. 1. Tool made by the Detroit Hexagon Drill Co. for boring Hexagonal Holes

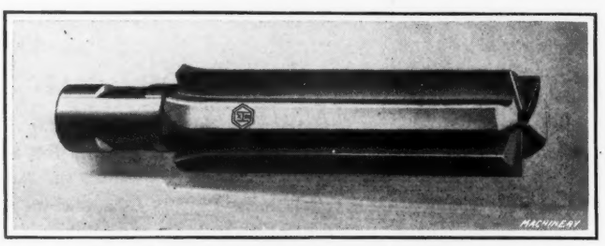


Fig. 2. Tool made by the Detroit Hexagon Drill Co. for boring Square Holes

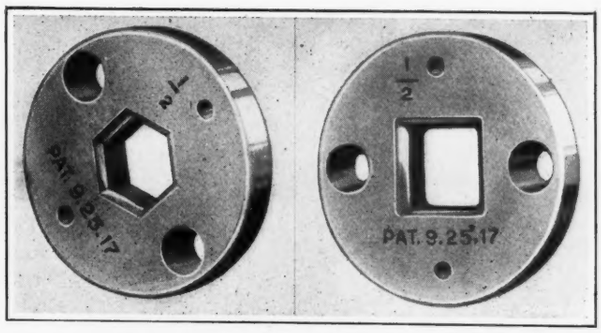


Fig. 3. Guides used with the Tools shown in Figs. 1 and 2 for boring Hexagonal and Square Holes

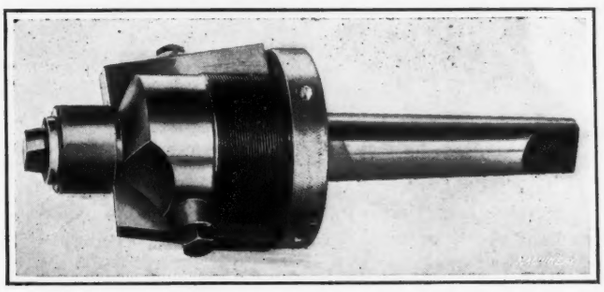
are shown in the accompanying illustrations, Figs. 1 and 2. Tools of this type can be used in various machines; for instance, they may be mounted in a drilling machine spindle where the tool revolves on a stationary piece of work, or the reverse condition may be successfully utilized, that is to say, mounting the tool stationary on a lathe or screw machine and revolving the work in contact with it.

As in the case of other tools of this general type, the principle of operation is to rotate the drill in a guide of the same shape as the hole to be cut. The drill is mounted in a special floating chuck which allows sufficient movement so that the cutting edges of the tool can generate the required shape of hole, the tool rotating successively on the heels of the lands to give the desired result. It is noteworthy that a drill of this kind only cuts with the edges at the front end of the tool, there being no cutting edges at the side. Drills of this type are adapted for speeds up to 350 revolutions per minute, depending upon the size of drill that is used and the kind of material in which it is working. Tools of this type have been successfully employed on steel, iron, brass, aluminum, micarta, bakelite, wood, marble, etc.

In most cases it will be found desirable when using tools of this type to first drill a round hole ⅛ inch smaller than the finished size of the square or hexagonal hole. This removes most of the excess metal from the hole and allows the use of a higher drilling speed with less strain on the tool. The square or hexagon drill is then put in the floating chuck, and the operation is performed in exactly the same way as when drilling a round hole. The speed should be about the same as for round-hole drilling. The floating chuck is made with a standard Morse taper shank.

GENESEE FACING TOOL

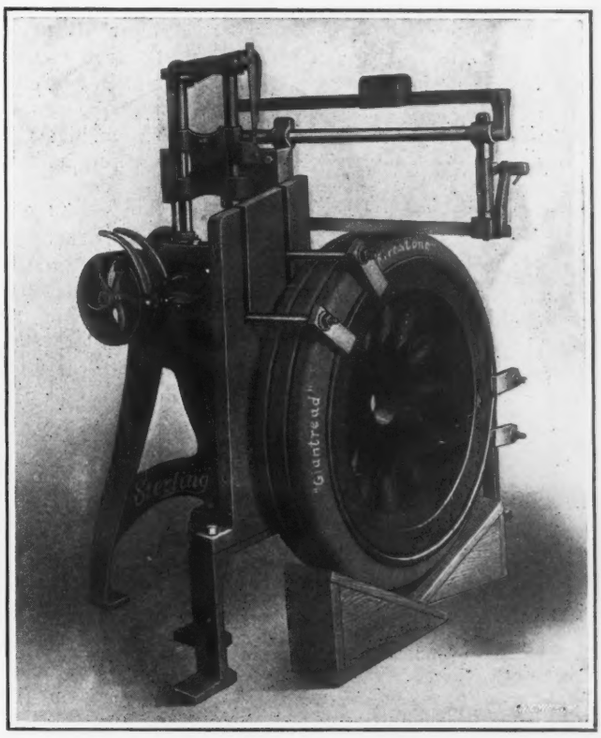
A combination tool has recently been developed by the Genesee Mfg. Co., Rochester, N. Y., which is adapted for the performance of counterboring, facing, forming, and similar operations. This tool is made of chrome-nickel steel, which is heat-treated to give it the best physical properties, and it is claimed that sharpening can be accomplished without requiring a special holder. Sufficient strength is provided to drive high-speed steel tool bits to the limit of its cutting capacity, and the tool-holder principle effects an economy in the use of steel. Tools of this type are made in Styles A and B, the Style A having two blades and the Style B three blades. With the exception of this difference in design, the dimensions are the same for both styles, which are made in four different sizes capable of facing diameters 1¼, 1⅝, 2⅜, and 3 inches, respectively. Either straight or tapered shanks can be furnished with all sizes of tools.



Combination Counterboring, Facing, and Forming Tool made by the Genesee Mfg. Co.

"STERLING" SAW FOR MOTOR TRUCK TIRES AND RIMS

To provide for cutting tires and rims off motor truck wheels, the Diamond Saw & Stamping Works, 357-361 Seventh St., Buffalo, N. Y., have recently developed the "Sterling" hacksaw machine which is here illustrated and described. It is stated that this machine will cut tires and rims from the largest truck wheels without causing any injury to the hub or spokes. Provision is made for using hacksaw blades from 17 to 25 inches in length, and 2 horsepower is sufficient to drive the machine. The arm that holds the saw blade is adjustable for different lengths according to the width of the tire. In operation, the truck wheel is simply rolled up to the large faceplate and clamped against it. A stop may be set before the cut is started, so that the blade will descend to the required depth, after which the feed movement is stopped, preventing any damage even though the machine is allowed to run indefinitely. Consequently, it is unnecessary to provide for constant attention, and it is also stated that unskilled workers can be employed to run a saw of this type. This hacksaw occupies a floor space of 5½ feet wide by 2 feet 8 inches long, and it weighs 855 pounds.

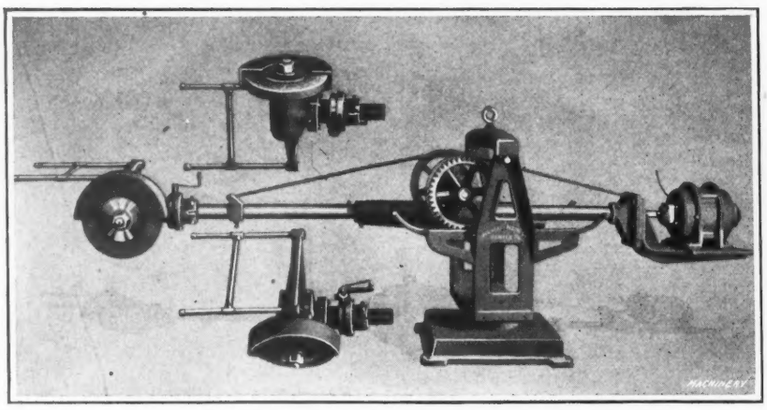


"Sterling" Hacksaw Machine built by the Diamond Saw & Stamping Works for cutting Motor Truck Tires and Rims

MUMMERT-DIXON RADIAL GRINDER

In the February, 1918, number of MACHINERY a description was published of the 8-inch portable radial grinding machine which was developed at that time by the Mummert-Dixon Co., Hanover, Pa. This firm has now added to its

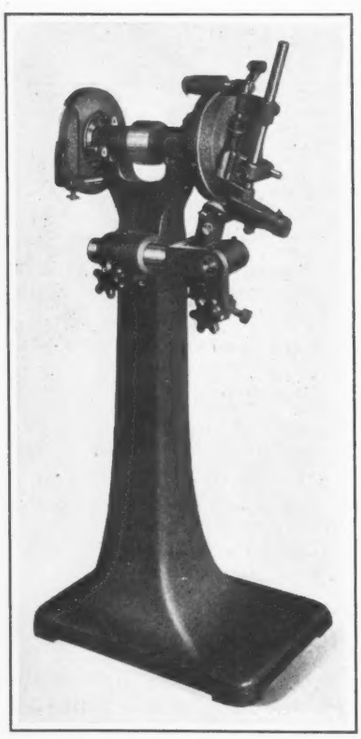
line a 20-inch by 3-inch machine which is intended for the same class of service. General features of this grinder are similar to those of the machine formerly described. It is self-contained and the frame is mounted on a substantial base. A trunnion is connected with the frame and turns in the base, with the thrust supported on ball bearings so that radial movements are easily accomplished. The grinding head is fitted with heavy-duty ball bearings, and the trolley cross-shaft is also mounted on this type of bearing. By turning a crank handle and worm which engages a worm-wheel, the head may be turned through a complete circle and held at any angle. This feature relieves the operator from holding the wheel at the working angle, and the crank is located in a convenient position to be easily turned. The head and motor come to a horizontal poise when released by the operator, due to the weight being suspended beneath the center of the cross trolley shaft. When carrying this machine with a crane, the cross trolley is held in a central position on the frame track by a locking pin in the frame, which engages the teeth of one of the trolley wheels. No moving parts are exposed, all running members being enclosed except the lower half of the grinding wheel.



Radial Grinding Machine built by the Mummert-Dixon Co.

GRAND RAPIDS TAP GRINDING MACHINE

For use in grinding the taper at the end of a tap and the clearance back of its cutting edges, the Grand Rapids Grinding Machine Co., 29 Ottawa Ave., N. W., Grand Rapids, Mich., has recently developed a machine illustrated in connection with the following description. The taper may be long in the case of nut taps, short in plug taps and practically negligible in bottoming taps, but the principle remains the same in each case. It is necessary for each land to have exactly the same angle of taper with just enough clearance or backing off so that it will cut freely. Reference to the illustration will make it apparent that the tap is held inclined at an angle to the side of the grinding wheel to provide for obtaining the desired degree of taper, and an oscillatory movement may be imparted to the work-holder to provide for backing off the lands of the tap.



Grinder built by the Grand Rapids Grinding Machine Co. for Use in grinding the Taper at the End of a Tap and the Relief back of the Cutting Edges

It is claimed that with the Grand Rapids tap grinder any desired angle of entrance taper can be obtained at the point of the tap, and irrespective of the degree of this angle, all flutes will be ground the same regardless of whether there are as few as two, or as many as eight. Either right- or left-hand taps can be ground on this machine, and it is adapted for handling taps of all types with the possible exception of certain staybolt taps. The threads may be U. S. standard, vee, S. A. E., Acme, square, etc. Sufficient capacity is provided for taking taps from ⅜ inch up to 3 inches in diameter, and it is merely necessary to mount the tap between centers, swing it to the proper grinding position against the movable stop and then oscillate the holder while the tap is in contact with the wheel. A spring tooth-rest provides for indexing from land to land, with the result that a tap can usually be ground in less than one-half the time that it would take to grind it by hand, if an attempt were made to secure a reasonable degree of accuracy.

ATLAS ARBOR PRESSES

In the accompanying illustrations there are shown two arbor presses which have recently been added to the line of machines built by the Atlas Press Co., 323 N. Park St., Kalamazoo, Mich. Fig. 2 illustrates a 15-ton power-driven arbor press, which is adapted for a variety of work, such as forcing arbors in and out of parts to be turned, for the performance of straightening and broaching operations, in assembling parts where forced fits are required, and for many similar purposes. In operating this press, the jaws are adjusted, the work set in place and the screw run down, after which power is applied by drawing down the lever and engaging a catch. As soon as power is applied to the work, the operator becomes sensible of a reaction on the lever which increases with an increase of pressure exerted on the work, and this enables him to "weigh the load," and to disengage the mechanism which applies power by releasing the lever. The rated capacity of this press is 30,000 pounds. It is often possible to accomplish light work by simply operating the handwheel, or on the power traverse machine this may be done by using the screw mechanism. Special bases may be

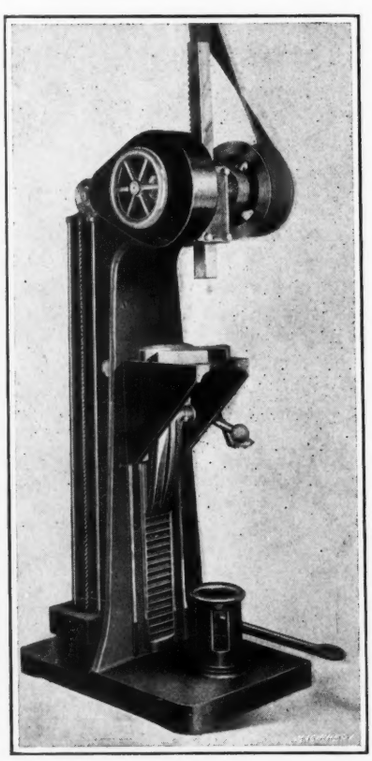


Fig. 1. Quick-acting 6-ton Arbor Press built by the Atlas Press Co.

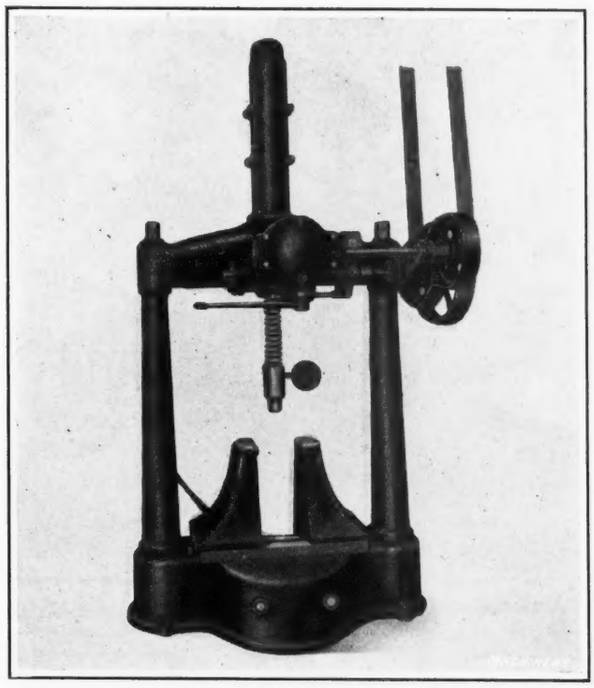


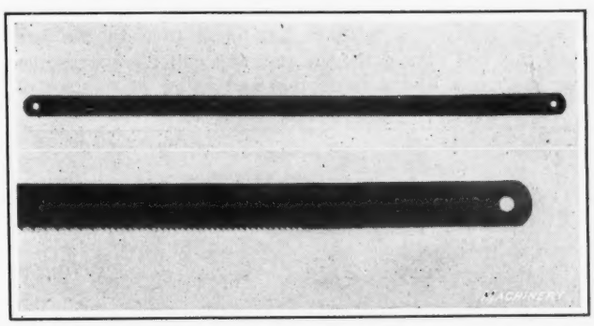
Fig. 2. Power-driven 15-ton Arbor Press built by the Atlas Press Co.

constructed to take care of different requirements and the length of the housings may also be increased.

Fig. 1 shows a quick-acting press for light production and assembly work, which is another recent product of the Atlas Press Co. It is operated by a foot-pedal which engages the friction clutch. All gears are cut with heavy stub teeth while the ram and pinion are made from steel which is heat-treated after machining. This press is always instantly accessible for use, being driven directly from the lineshaft, and pressure being applied by simply depressing the foot-pedal, or released by allowing the pedal to rise. A machine of this type may be used for various operations, such as forcing arbors in and out of parts to be turned, for straightening shafts, for the performance of light broaching operations and for assembling parts where forced fits are required. Should the work be of a delicate nature, a safety clutch is provided in the flywheel, and it may be adjusted by a small set-screw so that a very light pressure is applied, and pressure from this minimum up to the full capacity of the press which is approximately 12,000 pounds.

PEERLESS "DUPLEX" HACKSAW BLADES

While using a hand hacksaw on average work, a mechanic will usually start the cut by drawing the blade backward. This practice is said to dull the blade very rapidly, and it is to avoid this detrimental effect that some builders of hacksaw machines have provided mechanism to lift the saw clear of the work on its return stroke. It is also stated that there is a tendency for a hand hacksaw blade with teeth of the usual pitch to take a heavy bite while starting into the work. This tendency to take off too large a chip often results in "shelling" the teeth or breaking their points if the blade is not actually broken.

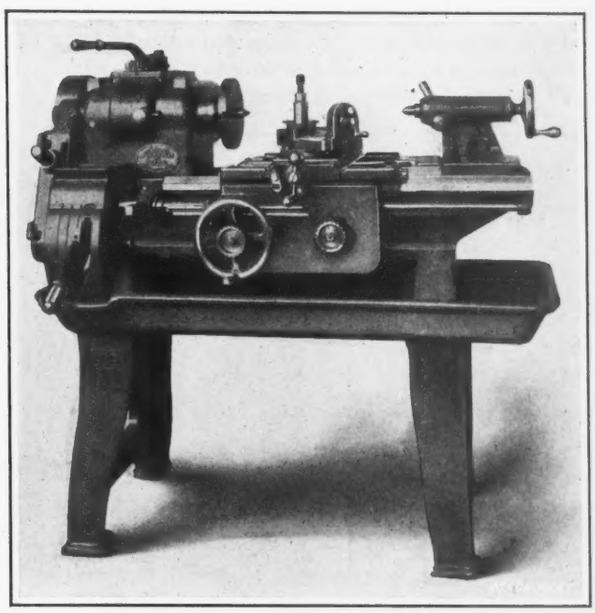


"Duplex" Hacksaw Blade manufactured by the Peerless Machine Co.

To overcome these defects the Peerless Machine Co., 1611 Racine St., Racine, Wis., has developed what is known as a "duplex" hacksaw blade with fine teeth at one end, which can be used for starting the cut. This arrangement effectively prevents the teeth from hogging into the work, and the cut is started easily and accurately. There is also said to be less tendency for the fine teeth to jump sidewise and start the cut inaccurately. Saw blades of this type are made in a combination 16 and 32 pitch in 10-inch and 12-inch lengths, of all hardened tungsten steel or carbon steel with a flexible back.

O. R. ADAMS "SHORT-CUT" LATHE

In the accompanying illustration there is shown one of the "Short-cut" lathes built by the O. R. Adams Mfg. Co., Inc., Norton St., Rochester, N. Y., which is equipped with a gear-box and power cross-feed. Six changes of speed are provided by gearing in the headstock, the range being from 43 to 375 revolutions per minute, and changes of speed can be made while the lathe is in operation. A two-speed starting lever makes it possible to vary the speed according to the diameter of the work, and when this lever is placed in a neutral position it applies a brake to the spindle. All of the gears are made of steel and run in a bath of oil. The spindle runs in adjustable tapered bronze bearings, and the thrust is taken on S K F self-aligning ball bearings.



"Short-Cut" Lathe built by the O. R. Adams Mfg. Co.

Four changes of feed ranging from 0.006 to 0.025 inch are provided by a tumbler type of feed-gear box, and by changing gears in a case at the end of the lathe a second series of feeds is available, ranging from 0.010 to 0.042 inch per revolution. The feed-gear case is assembled as a unit before mounting it on the lathe, and reverse gears are provided for changing the direction of feed. The cover over the gear-case at the end of the lathe remains closed by gravity. In designing the apron, the double-plate type of construction was employed which affords a double bearing for all shafts and studs.

Power longitudinal and cross feeds are provided through quick-acting frictions, and a multiple automatic stop for shoulder work, which is operated through clutches on the feed-shaft. On the carriage there is a lock for the cross-feed, which is conveniently located for the operator. The

cross-bridge is unusually wide and carries a cross-slide designed for either a compound or plain rest. Both the compound and cross-feed screws are graduated to 0.001 inch. Tools ⅝ by 1½ inches are used in the toolpost. A set-over type of tailstock is employed, and a taper attachment adapted for turning tapers up to 1½ inches per foot for the entire length between centers can be furnished as special equipment. When so desired, a front and rear toolpost, a back forming attachment, a draw-in chuck, or individual motor drive can be supplied.

LAPOINTE MACHINE TOOL CO.'S DUPLEX BROACHING MACHINE

A No. 3 duplex machine, which is shown in the accompanying illustration, has recently been added to the line of broaching machines built by the Lapointe Machine Tool Co., Hudson, Mass. It is adapted for use in factories where there are large quantities of work to be broached and where the conservation of floor space is important. As in the single machines of this company's manufacture, the operation is controlled through a patented clutch which affords a positive drive but is easy for the operator to manipulate. The actuating screws work entirely independently of each other, and they may operate separately or in unison, as required. Provision is made for regulating the stroke of either screw so that two different length broaches can be operated at the same time. Both screws are controlled by levers on the right-hand side of the machine, and the left-hand screw can also be independently controlled by a lever at the left-hand side. Either of two cutting speeds is provided by each screw, namely 49 and 74 inches per minute; and the return speed is 196 inches per minute. Thus little time is lost in waiting for the return of the screw.

All gearing is entirely enclosed, and the gears run in a bath of oil. An oil gage on the side of the machine shows the amount of oil in the gear-case. Large roller bearings support the end thrust of the nuts, thus reducing friction to a minimum. Brakes act on the clutches, eliminating any chance of the screws over-running on the return stroke, even while operated at a high rate of speed. The gears are always in motion and running in the same direction so that no additional power is required for stopping or starting. The draw-heads are made from steel billets and have long bearings on the ways of the machine, eliminating the possibility of chatter. These bearings are fitted with bronze shoes, which may be easily replaced when they become worn. A No. 4 B. & S. pump supplies a steady stream of lubricant to the machine while broaching, oil being drawn from a reservoir located in the front pedestal. Ball bearings support the single driving pulley, and if so desired the machine may be arranged for motor drive, the motor being mounted on a bracket at the side of the machine and transmitting power to a sprocket on the driving shaft by means of a silent chain. Sufficient capacity is provided on this machine for cutting, in steel, keyways up to 1½ inches wide, or for broaching square holes up to 3 inches across the flats from a drilled hole. The maximum stroke is 50 inches, and adjustment can be made to suit special requirements of the work. Allowing for the travel of the screw and broach, this machine occupies a floor space of 180 by 28 inches.

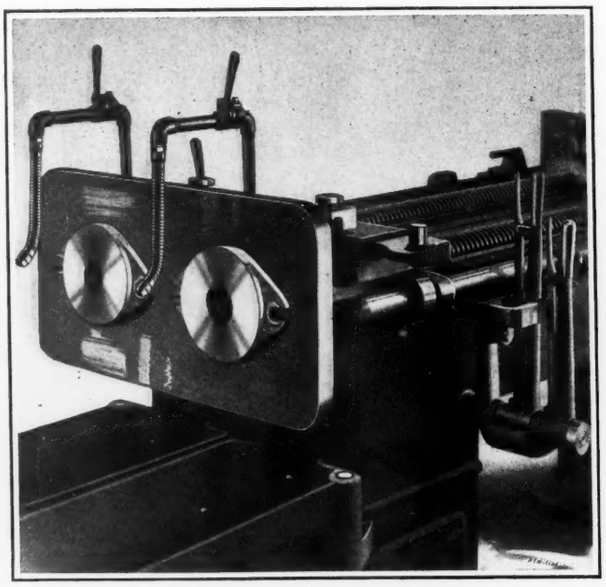


Fig. 2. Close-up View of the Operating Screws and Control Levers on Lapointe Duplex Broaching Machine

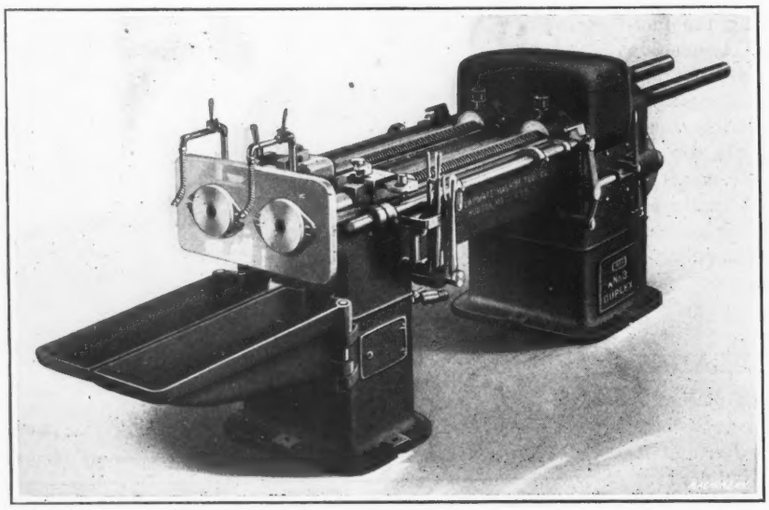
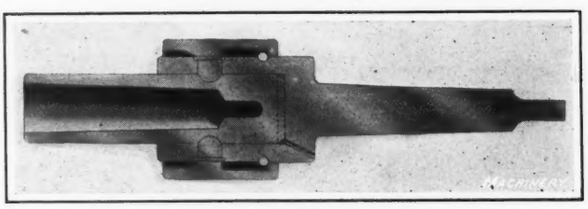


Fig. 1. No. 3 Duplex Broaching Machine built by the Lapointe Machine Tool Co.

QUICK-ACTION DRILL CHUCK

For use on drilling machines where it is required to use several different sizes of drills and other tools for the performance of successive operations on a piece of work, the Superior Collet Chuck Co., Grand Rapids, Mich., has developed a chuck shown in the accompanying illustration. It will be apparent from the illustration that this tool is arranged on the familiar principle of having a collet bored with a tapered hole on the inside to receive the shank of the tool, and furnished on the outside with means of engaging the driving pins or pawls with the collet. On the outside of the chuck body there is an engaging collar which is held in place by gravity and bears against the outer ends of the driving pins, thus holding them in engagement with the collet by which the tool is carried.

To change tools, the operator grasps the collar with his hand; and as this collar is free to rotate about the chuck body, he can lift it without having it turn in his hand. When this has been done, the tool and collet are withdrawn from the chuck and a fresh tool and collet pushed up into



Quick-change Drill Chuck made by the Superior Collet Chuck Co.

place, after which the collar is allowed to drop. An annular projection running around the inside of the collar comes in engagement with the outer ends of the driving pins, forcing them inward through the openings of the chuck body and into engagement with the tool-carrying collet, thus effecting the double purpose of holding this collet in place and affording a driving connection between it and the body of the chuck. In using a chuck of this kind, it is customary to have separate collets for each of the different tools which are used in sequence, so that the time lost in changing tools is reduced to a minimum.

RYERSON-GLADER WIRE NAIL MACHINE

In working out the design of the Ryerson-Glader wire nail machines which have recently been added to the line of machinery for which Joseph T. Ryerson & Son, 16th and Rockwell Sts., Chicago, Ill., are acting as sales agents, the provision of means for rapid operation and the accessibility of all parts for adjustment were regarded as highly important considerations. All members which are subject to severe strain or wear are made of steel and liberally proportioned, and the most important adjustments can be made on this machine while it is in operation. In operation, wire is taken automatically from a bundle or coil and fed between straightening rolls into the gripping dies. The wire is gripped and the head of the nail is formed with one blow of the heading hammer. As this hammer recedes, the straightener carriage moves forward through a distance equal to the length of the nail, and the wire is again gripped while the point cutting dies clip the wire off, making the point at the same time and leaving enough wire outside of the gripping dies to form the head of the next nail. In moving forward once more, the heading hammer operates an ejector which removes the finished nail from the machine. The wire is straightened by rolls moving back over the wire, while it is being held in the gripping dies, and by this method the machine is able to produce absolutely straight nails. To insure smoothness of operation, the crankshaft is counterbalanced to compensate for the thrust of the header crosshead, which is an important feature in high-speed work, as it practically eliminates vibration in the machine and in this way assures long life for the working parts. Equipment furnished with the Ryerson-Glader wire nail making machines consists of one pair of gripping dies for the largest size of wire nail to be produced by the machine and two pairs of point cutting dies. These point cutters can be used on all sizes of wire within the range of the machine, but the gripping dies have to be renewed for each change in the size of wire. No change of the gripping dies or point cutters is necessary in changing the length of nails to be produced.

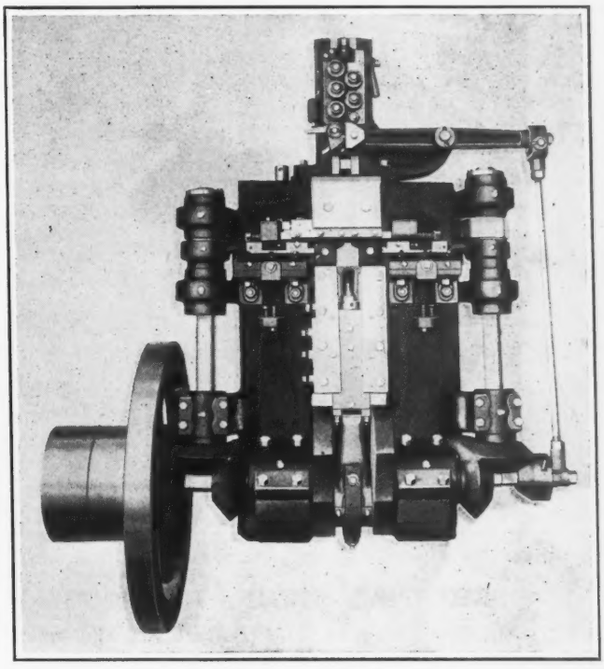


Fig. 2. Plan View of the Ryerson-Glader Wire Nail Machine

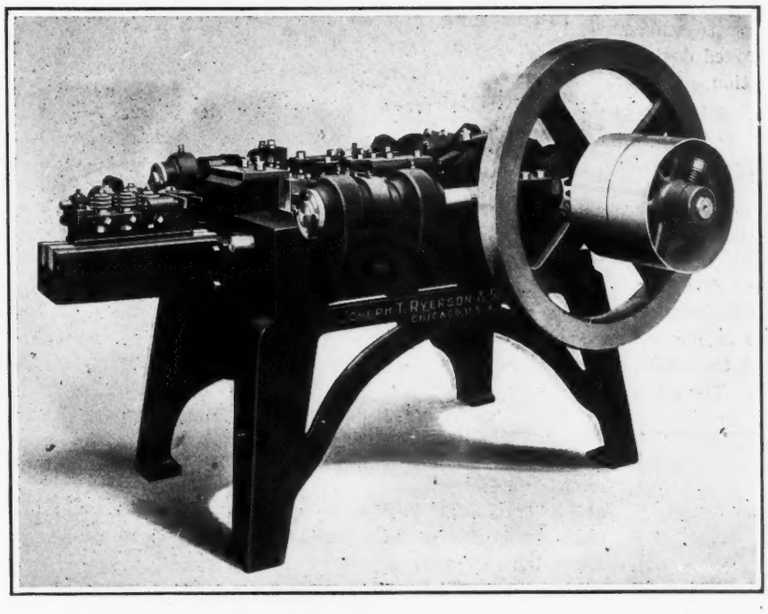
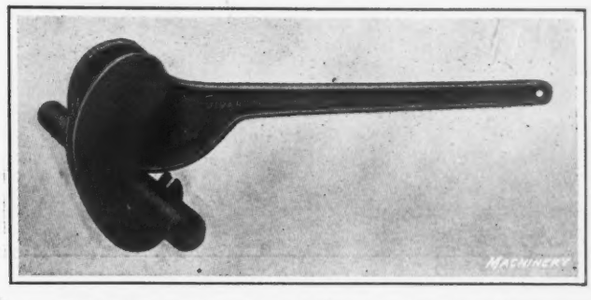


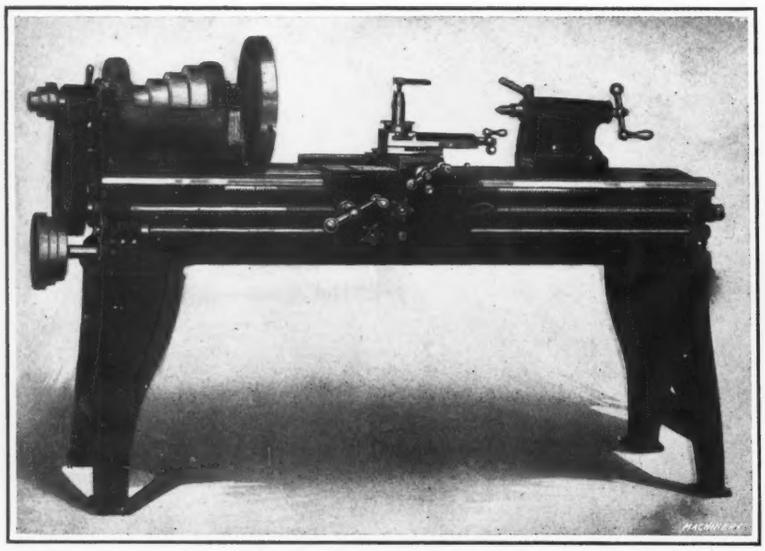
Fig. 1. Ryerson-Glader Wire Nail Machine for which Joseph T. Ryerson & Son have the Sales Agency

EFFICIENCY PIPE WRENCH

In the accompanying illustration there is shown a pipe wrench recently developed by the Efficiency Device Corporation, 203 8th St., Long Island City, N. Y. To prepare for using this tool, the jaws are hooked over the pipe and the wrench is pulled toward the operator, thus automatically opening the jaws and allowing them to pass over the pipe and close down to the working position by spring action. To remove the wrench, the operator pulls the handle toward him until the jaws open sufficiently to allow the wrench to be tipped sidewise, thus disengaging it from the pipe. This wrench is always ready for use on any size of pipe within its capacity without requiring any adjustments to be made. Attention is called to the fact that both the hook jaws and the surface of the cam are smooth, making this wrench desirable for use on smooth or finished pipe. These wrenches are made in two sizes, Nos. 10 and 11, with capacities for from ⅛- to ¾-inch, and from 1- to 1½-inch pipe and coupling, respectively.



Pipe Wrench made by the Efficiency Device Corporation



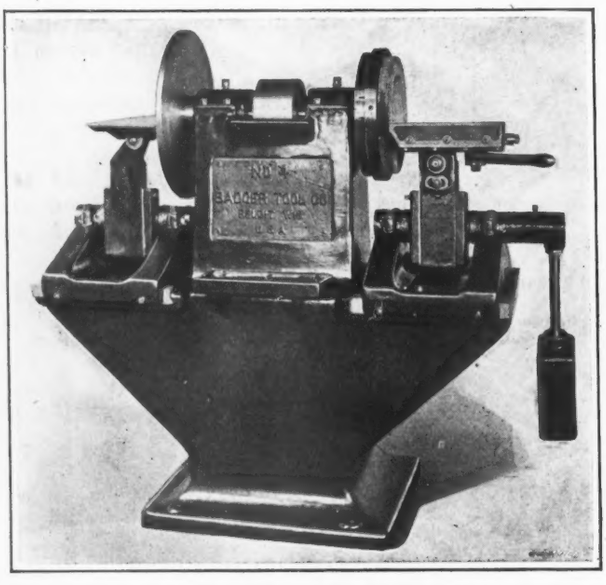
Engine Lathe built by the Sebastian Lathe Co. with a Semi-enclosed Type of Head

SEBASTIAN ENGINE LATHE

The Sebastian Lathe Co., 154 Culvert St., Cincinnati, Ohio, has recently modified the design of its engine lathe, one of the improved machines being shown in the accompanying illustration. The principal change from the preceding construction is in the headstock, which is made of the semi-enclosed type, affording greater rigidity than was attained with the previous design. Other features claimed for the improved Sebastian lathe are that there is not any strain or give between the two journals, because the headstock is so constructed that it ties these two members together. There are other minor changes, such as an improved design of the operating handles and in the construction of the apron, etc.

BADGER GRINDING MACHINE

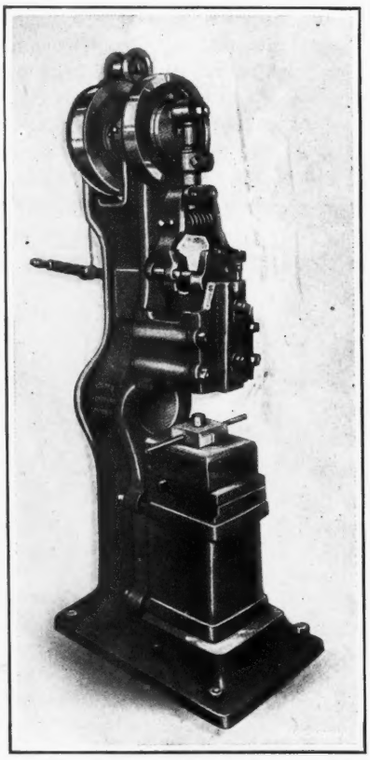
The accompanying illustration shows a No. 4 combination disk and ring wheel grinding machine which is a recent product of the Badger Tool Co., Beloit, Wis. This machine is of quite similar design to the No. 6 grinder of this company's manufacture which was mentioned in the September, 1919, number of MACHINERY. The present machine is adapted for disk wheels up to 18 inches in diameter, and the chuck capacity is for ring wheels 14 inches in diameter. The spindle is 2 inches in diameter and it is driven by a pulley measuring 7½ inches in diameter by 4¼ inches face width. It is mounted in combination radial and thrust ball bearings. The complete weight of the machine, countershaft and disk wheel press is 2300 pounds. It will be noticed that the grinder here illustrated is equipped with one disk wheel and one ring wheel, with a lever-feed table at the right- and a plain table at the left-hand side of the machine. Dust hoods can be furnished for dry grinding, or guards and pump connections for wet grinding.



No. 4 Combination Disk and Ring Wheel Grinder manufactured by the Badger Tool Co.

UNITED POWER HAMMER FOR PULVERIZING PIG IRON

In the accompanying illustration there is shown one of the Fairbanks power hammers built by the United Hammer Co., Oliver Bldg., Boston, Mass., which is equipped with a pulverizer designed for the use of chemical laboratories for preparing pig iron samples for analysis. It is claimed that this equipment is the means of saving a great deal of time and labor, as it is able to reduce ½- to ¾-inch cubes of metal in two or three minutes, producing particles that are fine enough to pass through an eighty-mesh sieve. A machine of this type may be equipped for belt drive or for motor drive. It is provided with a 100-pound ram and a 2-inch pestle and mortar. Operation is controlled by a foot-treadle at the base or by a special hand-operated starting device, either of which affords perfect control at all times. The capacity is for striking a blow of approximately 600 pounds while running at 300 revolutions per minute.



Fairbanks Power Hammer for pulverizing Pig Iron

GREENFIELD UNIVERSAL GRINDING MACHINE

In the accompanying illustration there is shown a No. 2 universal grinding machine which is a recent product of the Greenfield Machine Co., Greenfield, Mass. This grinder is adapted for all kinds of cutter, reamer, and tool grinding in addition to various cylindrical, internal, and surface grinding operations which come within its capacity. It is claimed to be a fully universal machine. The standard is a separate casting from the base on which it swivels, and the knee is splined to the standard so that these two members turn together and carry the slides with them. By tightening the two lower clamps, a positive vertical feed is obtained; and for the further convenience of the operator, the

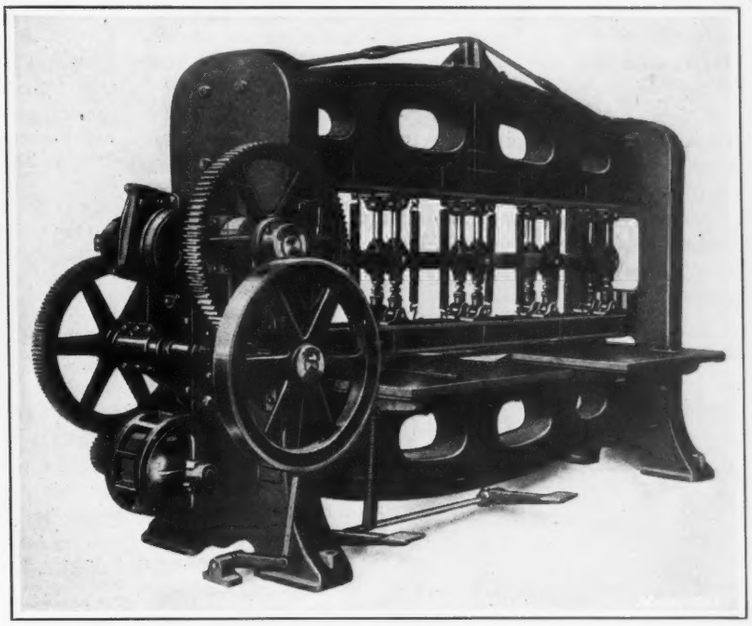
sleeve of the elevating handwheel is provided with graduations reading to 0.001 inch. The head swivels on top of the standard and is provided with witness marks at 90-degree intervals. Special attention is called to the design of this new head, which is cast in a single piece with a tie-bar across the top. It is also provided with tapered bronze boxes having means of adjustment for wear.

A tapered hole in each end of the spindle receives the wheel-holders, the spindle being ground and supported in bronze bearings which are protected from dust. Provision is made for end adjustment of the spindle bearings. The grinding wheels are held on tapered centers which are accurately ground, so that they may be removed from the spindle and replaced without difficulty in having the wheels run true. A full-length bearing is provided for the table on the longitudinal slide upon which it swivels; and there is a screw adjustment for accurately aligning the centers. Graduations are provided at the right-hand end so that settings may be made for taper turning operations. The graduations indicate tapers in intervals of ⅛ inch per foot. Longitudinal movement is secured by a rack and pinion, and cross movement by a feed-screw which is graduated to 0.001 inch. A wide range of attachments is provided for this machine to adapt it for performing various grinding operations.

No. 2 Universal Grinding Machine built by the Greenfield Machine Co.

STREINE FORMING AND ROOFING PRESS

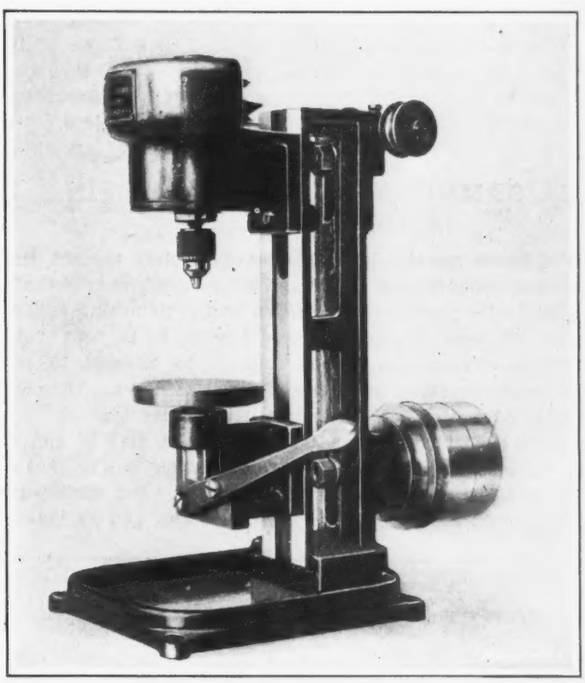
The Streine Tool & Mfg. Co., New Bremen, Ohio, has recently added to its line a toggle type of forming and roofing press which is here illustrated and described. This machine is made in 8-, 10-, and 12-foot sizes, for handling up to 10-gage stock, and in the same sizes for handling stock up to 16 gage. It is adapted for making all kinds of roofing and special shapes in any length up to the full capacity of the press, and ample die space is provided so that a wide range of work may be handled. There are four removable wooden tables supplied with gages on both sides of the machine, making it possible to use two kinds of dies at a single operation. The dies can be removed from either the side or end of the machine, as they are located by means of a tongue and groove arrangement which assures alignment. Both the forming bar and hold-down bar are well balanced with springs, and the toggles and shoes are accurately finished, allowing the machine to work very smoothly, the attainment of this result being furthered by the use of machine-cut gears and a positive clutch. The eccentrics are made of steel and keyed to the eccentric shaft. They are liberally proportioned with a wide face and ample bearing surface. A box type of cam is keyed to the eccentric shaft, making it possible to use a die under the hold-down bar for the forming of light gages of metal.



Forming and Roofing Press built by the Streine Tool & Mfg. Co.

BICKNELL-THOMAS TAPPING MACHINE

The Bicknell-Thomas Co., Greenfield, Mass., has added to its line a vertical tapping machine for bench use, which has

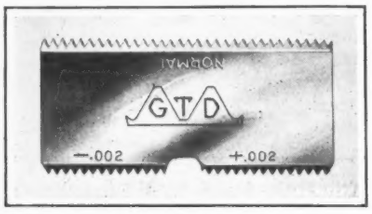


Vertical Tapping Machine built by the Bicknell-Thomas Co. for Use on the Bench

capacity for taps up to 3/16 inch in diameter. This machine is furnished with a sensitive friction driving mechanism that enables the operator to tap to the bottom of a hole without danger of breaking the tap. Driving power is furnished by a two-step cone pulley carrying a ⅜-inch round belt, and tight and loose pulleys for any desired speed. The spindle has a reverse speed of twice the forward tapping speed, and the work-table is easily operated by a lever. If so desired, the work-table can be removed and a special work-holding fixture substituted in its place. This machine is 15 inches high and weighs 48 pounds.

GTD LIMIT SCREW PITCH GAGE

The GTD limit screw pitch gage is a new development wherein the Greenfield Tap & Die Corporation, Greenfield, Mass., has taken the handy screw pitch gage, which has no tolerance but was cut to a normal lead only, and has made it more serviceable by providing two additional surfaces on the reverse side, one of which is cut with a lead 0.002 long and the other 0.002 short per inch, which converts it into a limit gage. When the old style of gage was laid in the thread of a screw, it was only possible to tell whether the lead on the screw was normal, but it was not possible to tell how bad the error was. With the new style of gage, if it is found that the thread tested is not normal, one can readily detect whether it is longer or shorter than the limit portion of the gage or whether the error is in between these limits. These gages are made for the present to control lead limits of plus and minus 0.002 per inch, which is the most generally used lead limit. Eventually it is also intended to supply them with tolerances of 0.001, 0.003 and 0.004 long and short lead.

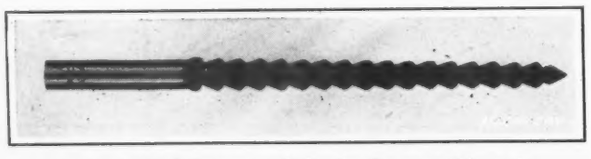


Limit Screw Pitch Gage made by the Greenfield Tap & Die Corporation

As these new limit screw pitch gages are solid and without moving parts, it is claimed that they are not likely to easily get out of order, and are in some ways preferable to flexible types of lead indicators. When using gages of this type, it is essential for the work being tested, as well as the gage, to be clean in the threads and for the gage to be held in the screw in a position parallel to the axis of the screw. In testing the thread with this gage, the work should be held up to the eye in front of a rather bright light, so that any error in lead can easily be noticed.

GAMMONS-HOLMAN TAPER-PIN HOLE REAMER

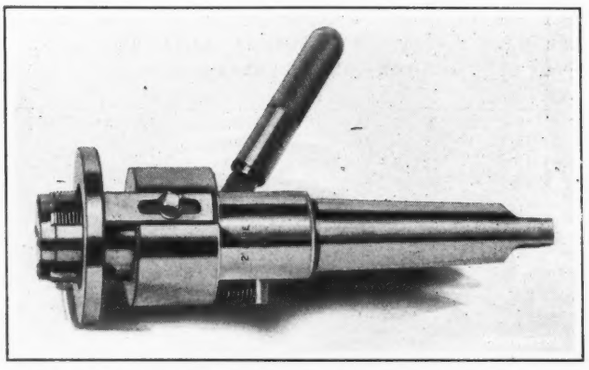
For use in reaming holes to receive standard tapered pins, the Gammons-Holman Co., Manchester, Conn., has recently placed on the market a tool known as the Gammons reamer, which is here illustrated and described. It will ream holes in any metal, and is claimed to be able to perform such operations with rapidity and accuracy. This tool is adapted for use in a vertical drilling machine or in a portable electric or pneumatic drill, and it may be run at any reasonable speed and feed. This reamer is also said to be useful for certain classes of diemaking. For such work a number of holes are drilled close together, and by enlarging holes with the reamer the intervening metal can be removed, thus producing an opening of any desired shape and providing the proper degree of clearance at a single operation. The standard degree of taper is ¼ inch per foot, but special reamers will be made with any required taper.



Taper-pin Hole Reamer made by the Gammons-Holman Co.

VICTOR COLLAPSIBLE TAP

The Victor Tool Co., Inc., Waynesboro, Pa., has recently placed on the market a collapsible taper-cutting pipe tap. Instead of using tapered chasers for securing the correct taper of the pipe thread, short straight chasers are employed, which automatically recede as they advance into the work. A correct taper is given to the thread by means of cams which regulate the receding of the chasers, so that instead of the entire length of the chasers cutting as it would be necessary for them to do if the job were done with a solid tap, the cutting strain can be taken up by a few threads only, as in cutting straight threads. As a result, no more power is required to cut a tapered thread than would be absorbed in tapping a straight hole. It is stated that this has proved an important factor on some difficult jobs where a considerable amount of power is ordinarily required for tapping tapered holes. This tap is said to have given exceptionally good results in tapping tough steel flanges. Taps of this style are made in any size from 2 to 12 inches.



Collapsible Taper-cutting Pipe Tap made by the Victor Tool Co.

DAVENPORT-SLOCOMB DIRECT-READING MICROMETER

On pages 678 and 679 of the March number of MACHINERY, a description was published of the direct-reading micrometer recently placed on the market by J. T. Slocomb Co., Providence, R. I. In this article a statement was made that the micrometer is equipped with a counting device which permits direct reading of every thousandth from 0 to 0.999 inch. The manufacturers of this tool desire to call attention to the fact that the counting mechanism used for this purpose is of a standard design which has been successfully used in various classes of service for many years. Although direct-reading micrometers are a new product of the J. T. Slocomb Co., instruments of this kind have been made by other manufacturers for several years. The feature of novelty on the new Slocomb direct-reading micrometer is the application of a counting mechanism of standard design for indicating the dimension of the work.

We have been informed by the Nielsen-Barton Chuck Co., 106 S. Jefferson St., Chicago, Ill., that the chuck illustrated on page 582 of the February number of MACHINERY under the name of the Barton drill chuck, was developed by the Nielsen-Barton Chuck Co. and not by the H. E. Barton Tool Co., as stated. The error was due to the fact that the description was sent us by the H. E. Barton Tool Co. and hence the tool was credited to them.

NEW MACHINERY AND TOOLS NOTES

Lathe Center: Senn Tool & Machine Co., 90 Shelby St., Detroit, Mich. A lathe or grinding machine center having interchangeable center points of heat-treated high-speed steel held in a body of carburized machine steel.

Drawing Pen: Bourquin & Co., 1345 Main St., Waltham, Mass. A drawing pen consisting of a swivel socket held in an ordinary pen-holder and supplied with interchangeable tubular pens varying in size from 0.012 to 0.090 inch.

Brake Attachment for Cowan Transveyors: Cowan Truck Co., 16 Water St., Holyoke, Mass. A "Raybestos" lined brake for application on transveyors of this company's manufacture, which can be operated by pressing down on the transveyor tongue.

Self-clamping Lathe Dog: Fraser-Duplex Mfg. Co., 1224 W. 6th St., Cleveland, Ohio. A lathe or grinding machine dog having two jaws supported on two posts. A tail or driver is fitted in the upper jaw which has an eccentric clamping lever for gripping the work.

Electrically Driven Coolant Pump: Fulflo Pump Co., Blanchester, Ohio. An electrically driven pump for use on machines equipped with the drainage systems of this company's manufacture. It can be attached as a unit at almost any convenient place, the current being supplied by attaching the motor cord to a lamp socket.

File Handle: Thurston-Bernay Co., Rialto Bldg., San Francisco, Cal. A line of file handles known as the "Skroo-Zon," made in nine sizes suitable for files from 2 to 16 inches long. As the name implies, the handles are screwed on, suitable threads being cut during the process by two dies contained in a pocket in the handle.

Shaft Coupling: Cincinnati Ball Crank Co., Cincinnati, Ohio. A compression type shaft coupling consisting of five parts, which can be used to connect shafts of various sizes by the use of interchangeable bushing strips. A desirable feature of this coupling is that it requires only the use of a hammer when installing or removing the coupling.

Foundryman's Torch: Mahr Mfg. Co., Minneapolis, Minn. A foundryman's torch for use in drying the skin of molds, which will project a blue flame of intense heat any distance from a few inches up to 5 feet. The torch operates equally satisfactorily on light fuel oil or kerosene, air pressure being supplied by means of a hose connection from any available source.

Semi-automatic Drilling Jig: Automatic Drill Tool Co., 549 W. Washington Blvd., Chicago, Ill. A drill jig for sensitive drilling machines known as the "Adjusto," that will hold and automatically eject, when the drilling operation is completed, round parts up to 1 inch in diameter, or odd-shaped pieces of equivalent size which do not require holes larger than 7/32 inch.

Lock Washer: Klingtite Mfg. Co., 37 Liberty St., New York City. A line of bell-shaped nut-locking washers known as "Klingtite," made in standard sizes from 3/16 to 1½ inches. The locking feature is obtained by first tightening the nut, then placing the washer over the projecting end of the screw and employing a sharp piece of pipe and a hammer to flatten it down against the nut.

Open-side Planing Machine: F. R. Patch Mfg. Co., Rutland, Vt. A 48-inch open-side planer, having a table 15 feet 6 inches long, a bed 23 feet 4 inches long, and a maximum height under the rail of 50 inches, with a vertical feed of 9 inches. A double-deck box type table is used, which is provided with T-slots and stake holes in the top deck only, and with openings at the sides for removing chips. The driving gears of the machine are entirely enclosed and run in a bath of oil.

Alligator Shears: Doelger & Kirsten, Milwaukee, Wis. A new line of automatic-stop alligator shears, designed to cut material on a bevel and supplied with special dies to suit the customer's requirements. Dies for cutting cold-rolled round, square, hexagon, flat, or bars of other shapes at right angles can also be supplied. A foot-lever controls the operation of the shears which are manufactured in sizes suitable for cutting material ranging from 1 to 5½ inches in diameter.

Gasoline Tractor for Industrial Plants: Towmotor Co., Bliss Road, Cleveland, Ohio. A gasoline tractor designed for use in industrial plants, equipped with a four-cylinder motor and provided with three speeds forward and one reverse, giving a speed of from 1 to 15 miles per hour. The wheel-base is 60 inches; length over-all, 90 inches; tread, 44 inches; width over-all, 52 inches; weight, 3200 pounds; and turning radius, 10 feet. The pulling capacity of the tractor under average conditions is sufficient to handle a load of from 10 to 15 tons.

Friction-head Screw Machine: Millholland Machine Co., Indianapolis, Ind. A No. 2 friction-head screw machine, which closely follows the lines of the other sizes made by this company. The swing over the bed is 14 inches, and over the cut-off 7 inches. The capacity of the automatic chuck for square stock is 11/16 inch, for hexagon stock ⅞ inch, and for round stock 1 inch. The hole through the spindle is 1 9/32 inches, the number of spindle speeds three, and the number of feeds obtained through the selective-speed gear-box, nine.

Trailer Truck: Warren & Irrgang Co., Springfield, Mass. Three sizes of trailer trucks of 2-, 3-, and 4-ton capacity, respectively. The 30- by 72-inch size has 12- by 3-inch wheels and will turn in a 4-foot circle. The 40- by 120-inch size will turn in a 6-foot circle and is equipped with 14- by 3-inch wheels. The trucks are designed for use in narrow aisles and for turning sharp corners, all four wheels being used in steering. They can be towed from either end, and are suitable for transporting heavy and bulky materials over rough floors and pavements.

Ship Bottom Riveting Rig: Liberty Tool Co., Munsey Bldg., Baltimore, Md. A supporting rig for a pneumatic riveter designed for use in riveting the bottom of a ship. The accessory is attached to the bottom of the ship by a single bolt, and consists of a round radius arm, supported at two points on convex rollers mounted in cross-heads, which may be adjusted up or down by crank handles at the ends of the brackets. The pneumatic riveter, supported by the radius arm, can be applied in any direction within a 20-foot circle. With this arrangement the operator is not required to support the tool, and can therefore maintain greater speed in riveting.

Internal Grinding Machine: Heald Machine Co., Worcester, Mass. A regular No. 70 internal grinding machine of this company's manufacture in which several improvements have been made, the most important of which is the incorporation of the friction clutch in the work-head, with the work driving pulley revolving on the spindle instead of being keyed to it. This feature not only enables the operator to start and stop the work more readily, but also facilitates the installation of these machines in the shop. The right-hand end of the ways has also been lengthened 4 inches. The wheel guard has been redesigned to give the operator better protection, and the handwheel for operating the table has been increased in diameter to give greater leverage.

Horizontal Boring Machines: Moline Machinery Co., Moline, Ill. Two horizontal boring machines especially adapted for boring crank and transmission cases. The No. 4 machine, when equipped with rail and horizontal adjustable heads, is adapted for boring a series of holes in work which can be conveniently tilted to bring the holes in a horizontal plane. The No. 5 machine is intended for use where two or more holes, not in a horizontal plane, are to be bored. This machine has a solid head furnished with spindles grouped to suit the purchaser's requirements. The spindles of both machines have two speeds, and the tables are provided with three positive feeds and rapid traverse in both directions. The table has a working surface of 24 by 48 inches and a travel of 48 inches.

* * *

AERONAUTIC MEETING OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

The Society of Automotive Engineers held a technical session relating to aeronautics at the Engineering Societies Building, 29 W. 39th St., New York City, March 10, with both afternoon and evening sessions. At this meeting a great number of important papers were read, and interesting motion pictures were a part of the afternoon session. The papers presented were as follows: "Possible Airplane Performance with Maintenance of Engine Power at All Altitudes," by Colonel V. E. Clark; "Consideration of Landing Run and Getaway by Standard Type Airplanes," by Alexander Klemin; "Effect of General Shape of Aviation Engines on Operation of Airplanes," by Grover C. Loening; "Some Factors in the Design of Airplane Radiators," by S. R. Parsons; "The Heat-treating of Brazed Fittings for Aircraft," by Archibald Black; "Flying an Aviation Engine on the Ground," by S. W. Sparrow; "Military Aeronautics," by Major General C. T. Menoher, U. S. A.; "Naval Aeronautics," by Commander G. C. Westervelt, U. S. N.; "Aeronautics from the Commercial Viewpoint," by George H. Houston; "Some Phases of Civil Aeronautics," by Major Maurice Connolly. In addition to these papers a report was presented by the Aeronautical Division of the Standards Committee, of which H. M. Crane is chairman.

Employes' Representation and Shop Committees

The National Industrial Conference Board, 15 Beacon St., Boston, Mass., has published a research report entitled "Works Councils in the United States," containing a great deal of information relating to the results obtained by employes' representation and shop committees in the United States. "Of the numerous plans for improving the relationship between employers and employes and for increasing the efficiency of industrial production," says the report, "few are attracting more widespread interest than that of securing for employes a voice in the adjustment of working conditions through the instrumentality of committees or councils." This movement is variously referred to by such terms as "Employe Representation," "Democracy in Industry," "Industrial Democracy," "Shop Committees," or "Works Councils."

THE report recently published by the National Industrial Conference Board on employes' representation and shop committees presents a description and analysis of this form of industrial organization as it exists today in the United States. In view of the fact that the experience with employes' shop councils has been comparatively brief, the report does not aim to present conclusions, but merely to record, in an impartial manner, the developments of a movement which is demanding the attention of industrial leaders in many parts of the country. The report is not intended to express the opinion of the National Industrial Conference Board on the desirability or value of employes' representation on Works Councils. It is believed that a more extended experience with this form of industrial organization will be required in order to obtain a more reliable basis for judgment.

Up to the period of the war the Works Council was practically unknown either in the United States or in Great Britain. While the number of establishments having Works Councils today is still relatively small, at the present time such organizations are known to exist in this country in more than 200 establishments employing about 500,000 workers, and their organization has progressed even more rapidly in Great Britain.

It is believed that the term "Works Council" best describes this new form of industrial organization. The expressions "democracy in industry" and "employe representation" obviously are too generic in that they designate the movement and not the specific form which it has assumed. The name "shop committee" is misleading in that it does not distinguish between "employe representation," "trade union," or technical shop committees. The term "Works Council" appears to be properly inclusive as well as definite and exact, and is therefore used in the report under review. The recent growth in the number of Works Councils, as well as the importance of their aims, gives to the study of this form of industrial organization a timely and vital interest.

Essential Nature of Works Councils

The Works Council may be described as a form of industrial organization under which the employes of an individual establishment, through representatives chosen by and from among themselves, share collectively in the adjustment of employment conditions in that establishment. The Works Council is intended as one means of satisfying the desire of the worker for a share in the adjustment of his working conditions; as a means of lessening labor difficulties, of allaying industrial unrest, of increasing productive efficiency; and as an opportunity for informing employes on production, and technical and economic questions. It provides, in the individual establishment, an organized form of contact between the employer and his employes.

Works Councils vary widely in their form and in the scope of their activities, but one characteristic is common to all, namely, the election of the employes' representatives by and from among the workers themselves on a democratic basis of representation. For this reason, committees of employes appointed by the management are not considered in this report. Similarly, trade union shop committees are excluded, since, instead of being elected by the workers of the individual establishment on a democratic basis, they are chosen by the organized workers only, or by trade union members irrespective of their employment in the particular establishment.

The institution of the Works Council obviously involves acceptance by the employer of the principle of collective dealing. Under a plan of employe representation, questions previously settled between the employer and his employes individually are handled by representatives of the employes collectively, and moreover, on a systematic basis. Recognition of the principle of collective dealing by the employes of individual establishments with their employer forms the very basis of the Works Council. Such collective dealing is, however, distinct from "collective bargaining" in the sense of collective dealing with labor unions as organizations.

The Works Council, however, is not in its essence a substitute or an alternative for labor union organization. In recognition of this fact, some notable plans of employe representation expressly provide that employes shall not be discriminated against because of labor union membership. While the Works Council tends to restrict the activity of the labor union in matters purely local to the individual establishment, the union may still be potent in settling problems common to the entire craft, industry or locality.

Clear distinction should be made between a Works Council and the occasional meeting of an employer with committees or deputations of his workers, only when some exigency arises. In other words, the contact between management and men established by a Works Council is on a definitely organized and sytematized basis and is continuous.

Evolution and History of Works Councils in the United States

The influences which have resulted in the formation of Works Councils were active long before these organizations themselves developed. For years before the first Works Council was established in the United States, employers had organized or had encouraged their employes to form clubs or associations for social purposes; some employers had provided for the participation of employes in industrial betterment activities. Moreover, for many years prior to the appearance of the first Works Council informal deputations of workers had in many establishments been a customary means of adjusting differences between employer and employes; again, trade unions had maintained shop committees to represent the interests of their members in individual establishments.

What, apparently, was the first suggestion of a Works Council in this country appeared in 1886 in an article on "The Shop Council," by James C. Bayles. The writer laid before employers and wage-earners what he termed "a simple, inexpensive and perfectly practical method" of adjusting labor difficulties. He described in detail the functions and

membership of a Works Council consisting of four members, two elected by the wage-earners and two by the management. The chairman was to be chosen by these four members and he was not necessarily to be otherwise connected with the plant. Apparently this plan was never put into practical operation.

The earliest Works Council in the United States of which any record has been found was introduced in 1904 by the Nernst Lamp Co., in Pittsburg. The plan provided for a "factory committee" composed of representatives from the clerical force, from the factory operatives and from the foremen, with the superintendent of the plant as permanent chairman. The management of the company has since changed several times and the committee has passed out of existence.

In the fall of 1913 the Packard Piano Co. of Fort Wayne, Ind., after experiencing a period of labor difficulties, introduced in its works a plan of industrial representation patterned after the organization of the Federal Government. A "Business Policy" was formulated by the management and submitted to the employes, who voted upon its adoption. It took effect in the late fall of 1913 and is still existent. In 1914 the Printz-Biederman Co. of Cleveland introduced a similar plan, which in somewhat modified form is still effective. Since that time the idea has been constantly growing.

Number of Works Councils in Operation

According to the report here reviewed, there are 225 Works Councils in operation in the United States; Connecticut leading with 58; Ohio, Illinois, and Pennsylvania following with about 20 each; the remainder being mainly in Michigan, New York, Massachusetts, and Wisconsin. In each of the nine industrial states which lead in the number of Works Councils, the majority of these organizations are found in the metal trades, there being altogether 144 Works Councils in these trades, of which 56 are in the machine building and tool making field; 20 in the iron and steel mills; 14 in the sheet metal, wire and wire product industries; and 12 in the machine part making industries.

It is also interesting to note the number of employes in the plants where Works Councils are established. In counting the 122 plants for which the number of employes is reported, it is found that 44 had less than 500 employes; 47 had from 500 to 3000 employes; 18 from 3000 to 10,000 employes; and 13 over 10,000 employes. Altogether Works Councils are established in industries employing about 500,000 workers.

Distribution with Respect to the Extent of Trade Unionism

Of the 81 plants from which information was secured on this point, 71 were reported as open shops, while in 3 others one or more departments were conducted on the open-shop basis; 3 were closed non-union shops (whatever that might mean); another is reported as a closed shop maintained by a company union; 2 were closed union shops; and 1 a preferential union shop.

After having reviewed the extent to which the Works Council idea is employed in the United States, the report continues by giving details of the plans operated in various plants, outlining the authority that is given to the Works Council, showing the functions and activities as well as the results obtained. Anyone who wishes to study this subject in detail, should obtain from the National Industrial Conference Board, a copy of the report, which covers 132 pages and is the most complete review of this movement that has so far been compiled.

* * *

A new journal entitled *The Woman Engineer* has appeared in England, the object of which is to encourage and stimulate the interest of women in the engineering profession and to remove the prejudice and artificial restrictions which now prevent women from taking up engineering as a trade or profession. The journal is published by the Women's Engineering Society, 46 Dover St., Piccadilly, W. 1, London.

CARE AND OPERATION OF A BAND SAW IN A PATTERN SHOP

By M. E. DUGGAN

Patternmakers are, as a rule, accustomed to allowing considerable material beyond the finish line when employing the band saw to cut out wooden parts. This practice makes it necessary to spend considerable time in finishing the parts down with hand tools, such as the plane or chisel, when as a matter of fact the required finish could be obtained by sawing up to the line. It may nevertheless be difficult to convince some patternmakers that this can be done unless they are afforded an opportunity of seeing the practical application of this method.

The benefit to be derived from a properly cared for and operated band saw in the pattern shop may be illustrated by the following experience of the writer. The manager of a certain pattern shop contracted to make several thousand pieces in wood, basing his price on the assumption that the work would all be performed on the band saw, but when the patternmaker was confronted with the work, he decided that the only satisfactory method of producing the pieces would be to first cut them out on the band saw to approximately the correct size and shape, and afterward finish the pieces accurately by means of a cutter-head especially designed for this purpose.

The work proceeded satisfactorily in this way until the band saw broke. As it was necessary to maintain the output, the material and "finished size" templets were sent to a nearby furniture factory where the work was continued, but in a different way. The band saw operator in the furniture factory, knowing nothing about the finish allowance or the cutter-head, cut the pieces out to finish size directly with the band saw, eliminating all additional hand-finishing work. When the foreman found out how the work was being done, and that the parts could be assembled satisfactorily, he became convinced that with the right kind of band saw operated by a careful workman, it was possible to cut right up to the finish line and thus avoid unnecessary hand fitting.

In order to keep the band saw in good condition so that it may be used for accurate work, the following rules should be observed: (1) Always use a roller saw-guide and never a stationary one. (2) Make sure that the saw is only just permitted to touch the roller lightly. (3) Use a ¼-inch saw for cutting light as well as heavy stock. (4) Never use saws which are kinked, bent, or humped at the brazed joints. (5) Test the truth of the saw for cutting square by sawing a 3-inch diameter cylinder from a piece of wood 6 inches thick, an operation which cannot readily be performed with a wide saw, or one that is incorrectly set or filed. (6) See that the bands on the wheel are never allowed to become gummed. (7) Oil every sliding bearing and journal bearing each morning.

* * *

A writer in a contemporary journal is rather amused by a story published in a recent number of a British journal, in which the making of automobiles turned out in quantity at $250 a piece is described. The story is dated 1930 and the idea that automobiles may be built at so low a price is apparently considered beyond possible expectations. It should not be forgotten, however, that there are automobiles sold in the United States today by the hundred-thousands at a price, which, figured at the value of a dollar on a pre-war basis, would not be much, if any, in excess of $250. In fact, this very automobile was sold in 1917 for slightly over $300, and certainly it was produced for less than $250 in order to make such a selling price possible. Hence, the British writer is not so much ahead of his time after all, and it is reasonable to expect that with the constantly increasing use of automatic machinery, improved methods of efficiency, and simplification in design, automobiles will be produced in the future at a price much lower than the average cost today.

APPLICATIONS OF PRESTWICH FLUID GAGES

The interchangeable manufacture of numerous parts that must be machined within close tolerances, such as automobile engine and ball bearing parts, has led to the development of many types of gages and measuring instruments for testing the accuracy of the finished product. Three applications of the well-known fluid gage or prestometer made by the Coats Machine Tool Co., Inc., 110-112 W. 40th St., New York City, are shown in Figs. 1, 2, and 3.

Fig. 1 shows the prestometer adapted for ascertaining the size, concentricity, and parallelism of the bore of the inner race of a ball bearing. This instrument is provided with an anvil block having a special nose-piece *A* upon which the part is placed for inspection. This nose-piece is detachable so that one of another size can be readily substituted when it is desired to use the instrument for inspecting races of a different size. There is a floating lever inside the anvil, one end of which comes in contact with the bore of the race. Another surface of this lever registers contact with anvil *B* attached to the diaphragm of the fluid chamber so that when a part is being measured the fluid is raised in the usual manner. The pencil indicates the position of the end of the straight portion of the anvil nose-piece. The limits on this work are very close, being 0.0002 inch plus and 0.0001 inch minus, and so a glass tube having a very fine bore is used which magnifies 3000 diameters. Each graduation on the scale represents 0.0001 inch, the actual distance between each graduation being 0.3 inch, so it is evident that very slight inaccuracies of the work can be readily detected by this instrument. The total range of this scale is 0.001 inch.

Another example of prestometer application is illustrated in Fig. 2. The instrument in this case is employed in inspecting the external cylindrical surfaces of a 4½-inch diameter automobile engine piston. The difference between the minimum diameter allowed for the first land, which is the smallest dimension to be checked, and the maximum diameter allowed for the body of the piston, which is the largest dimension, is 0.022 inch. The tolerance on each measurement is 0.001 inch, and so the scale is graduated to represent measurements of 0.001 inch, there being twenty-two graduations so that the measurements of all the surfaces are within the capacity of the scale. The maximum and minimum points between which the fluid must be raised for each surface are marked on the scale. The glass tube provided on this machine magnifies 250 diameters, and the scale graduations are actually ⅛ inch apart.

Attention is called to the ball in the base toward which the pencil in the illustration is being pointed. This ball is ⅜ inch in diameter and is provided with an adjustment so that it can be projected a certain amount above the surface of the base. This amount should be slightly greater than one-half the total variation between the diameters of the different surfaces to be measured, so that the piston will always be resting on the surface being inspected and not on the body portion which, as was previously mentioned, is larger in diameter than any of the other surfaces. As the total variation between the surface diameters in this case is 0.022 inch, the ball is projected slightly more than 0.011 inch above the base surface. The piston is inspected by sliding it along the base so that the various surfaces to be measured come between the ball in the base and the ball point *A* which is attached to the front end of a floating lever. As this lever is raised by coming in contact with any of the piston surfaces, a rear portion of it comes in contact with the anvil on the diaphragm of the fluid chamber which, in turn, causes the fluid to be forced up into the glass tube. A single pointer is provided with this arrangement to indicate the normal position of the fluid. The piston should be placed with the wrist-pin holes in a horizontal position for the inspection. The piston is relieved on the two sides adjacent to the piston-pin holes. When these holes are brought into a vertical position, the fluid in the glass tube rises to between the points marked "clearance."

Another interesting application of this instrument is illustrated in Fig. 3. The various attachments supplied in this case are for the purpose of adapting the instrument to the inspection of an internal surface of an automobile pinion-shaft housing. The work is slipped over mandrel *A*, which is provided with strips to suit the diameter of a smaller internal surface of the work, and the accuracy of the bore to be measured is determined by means of pins *B*. These pins operate a floating lever that also contacts with the anvil of the fluid chamber diaphragm so that the fluid is raised in the glass tube by the usual method. One advantage of this method of inspection for a part of this type is that the bore can be accurately measured regardless of whether it is concentric with the periphery of the part. Another reason for placing the work on a mandrel is because the outside surface of the housing is slightly tapered, which does not readily permit it to be supported on V-blocks for the inspection.

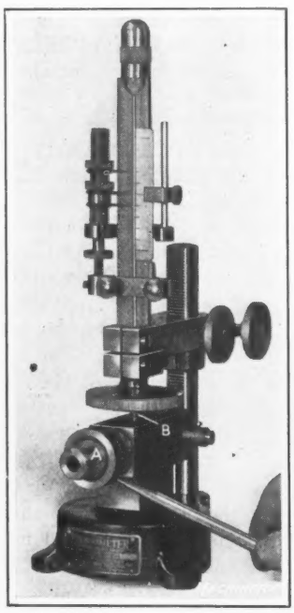


Fig. 1. Prestometer being used in inspecting the Bore of Ball Bearing Races

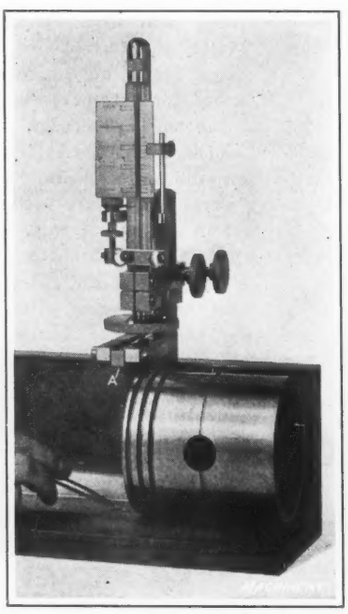


Fig. 2. Application of the Fluid Gage in determining the Accuracy of Automobile Pistons

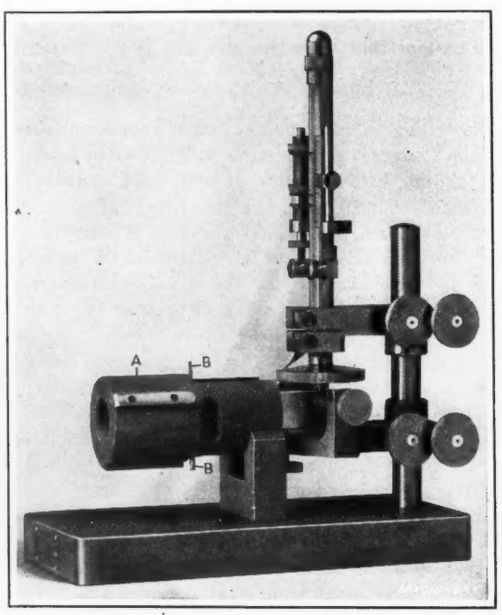


Fig. 3. Adaptation of the Prestometer to the gaging of an Internal Surface of an Automobile Pinion-shaft Housing

BRITISH GEAR-SHAPING MACHINE

The illustration Fig. 1 shows a new gear shaper brought out by Jones & Shipman, Ltd., Leicester, England. The machine operates on very simple lines, and has been designed for all classes of repetition work on internal and external gears or ratchets. It is entirely automatic in operation, and is claimed to need little attention beyond setting the work and tools. The main frame of the machine is a single casting bolted to a circular cast base which can be mounted on a bench or column. The base is cast with a deep channel for cooling liquid. Fig. 2 shows a side elevation and an end view of the machine. A single belt drive is used, a tight and loose pulley being provided at *A* to permit the machine to be stopped and started by simply shifting the belt. The shaft on which the pulleys are mounted is equipped with a handwheel, which provides a convenient means of operating the machine by hand when setting up. The tool-slide *B* runs in guides, one of which is adjusted by a taper gib. The sliding position relative to the bed can be varied to suit different classes of work, and is effected by the squared end on a screwed shaft mounted in the slide. The position is locked by the handle on top of the slide.

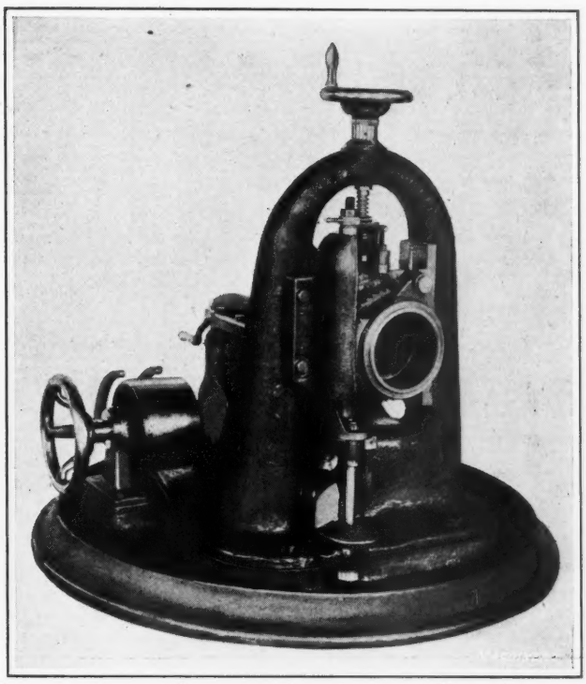


Fig. 1. Gear-shaping Machine designed for cutting Spur and Internal Gears

The tool-slide is reciprocated by a slotted lever *C* pivoted in the main frame. The length of stroke is between 0 and 4 inches, and is varied by adjusting the position of the block *D* along a slot in the driving wheel *E* driven by a 3 to 1 reduction from the pulley shaft. The division around the work is carried out by means of a ratchet, clearly seen in Fig. 1. The pawl *F*, engaging the ratchet, is carried by a rotating sleeve provided around part of its circumference with teeth which engage a rack cut in the vertical plunger *H*, normally pressed downward by the coil spring seen above the rack. The toe of the plunger is engaged by a horizontal cam *J*, driven through a train of bevel and spur gears from the shaft operating the tool-slide. The cam makes one revolution for each complete reciprocation of the tool, and is timed to raise the rack when the tool is at the back end of its stroke. Thus the pawl advances the work to allow each succeeding tooth to be cut.

The handled nut and locknut, seen at the top of the plunger, provide adjustment by raising or lowering the normal position, so that a shorter or longer length of cam face contacts with the plunger, giving a corresponding variation to the feed of the pawl, according to the number of divisions required around the work. Once in every revolution of the work the feed-finger *K* engages with the adjustable pin *L*, and advances the feed-pawl *M*, which is mounted on a rocking arm. The feed-pawl engages a feed-wheel *N* having 100 teeth. Each tooth advance feeds the work carriage downward between the frame uprights

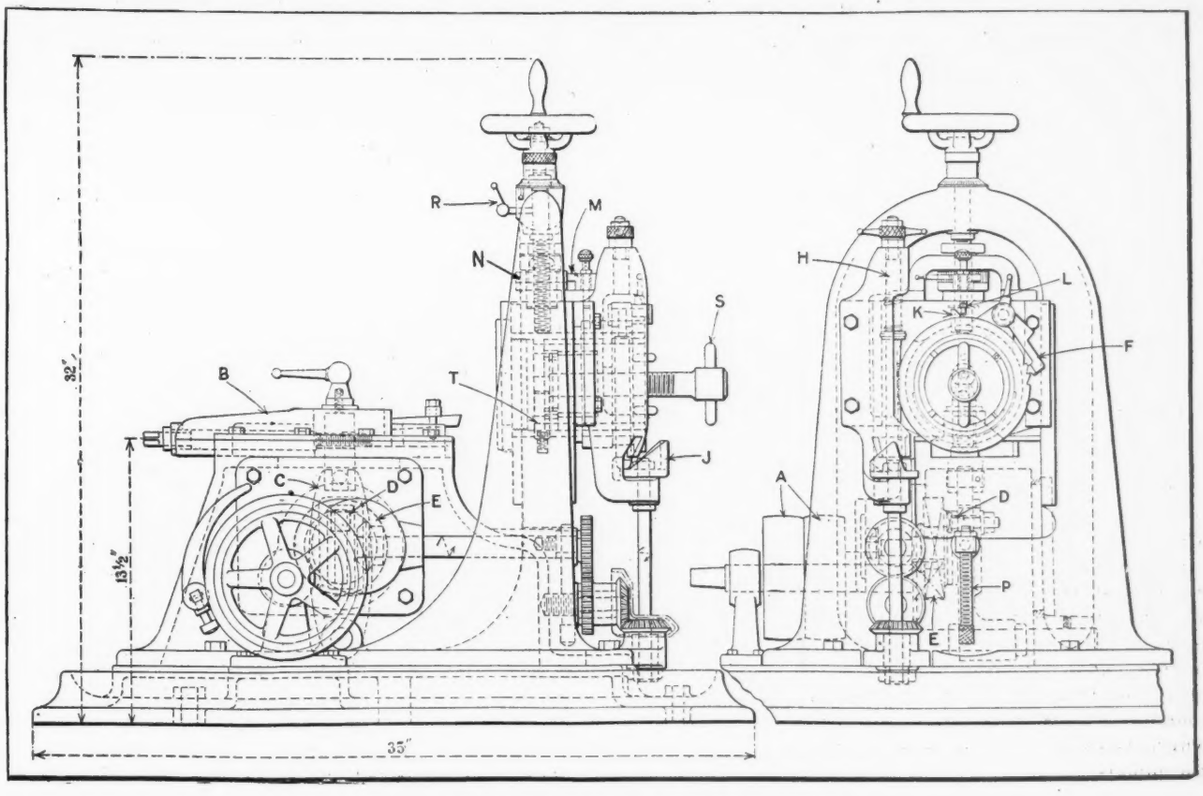


Fig. 2. Side and End Elevation of Gear-shaping Machine

0.0025 inch. When the work has rotated a sufficient number of times to give the requisite depth of tooth, the adjustable stop *P* prevents the cut going deeper. If the machine should be left running at this stage the feed-wheel *N* would rotate idly between fiber friction washers which are in contact with its sides without advancing the carriage. By unlocking *R* the carriage can be raised or lowered by the handwheel shown on top of the machine, a micrometer disk being provided to facilitate setting. Three methods of holding the work can be used, which adapt the machine for cutting either internal or regular spur gears.

Internally cut gears are mounted in a chuck screwed into the large hollow spindle, and secured by a screwed lock-ring. The extremely large hole of 5 inches through the spindle enables the work in many cases to be inserted from the back of the machine, a threaded pin bearing on a clamp plate being used to secure the work. The block carrying the pin is inserted in the spindle and secured by a quick-acting gate lock. A friction brake *T* is provided to prevent the spindle over-running after rotation by the ratchet.

The following are the dimensions and capacity: Chuck capacity, 5 inches diameter; number of teeth with one cam, 16 up to any number required; diametral pitch of teeth, 10; vertical feed, which is always downward, 3½ inches; stroke of tool-slide, 0 to 4 inches; pulley size, 6 by 2 inches face, 360 revolutions per minute; over-all height, 32 inches, without column; bed, 35 inches in diameter.

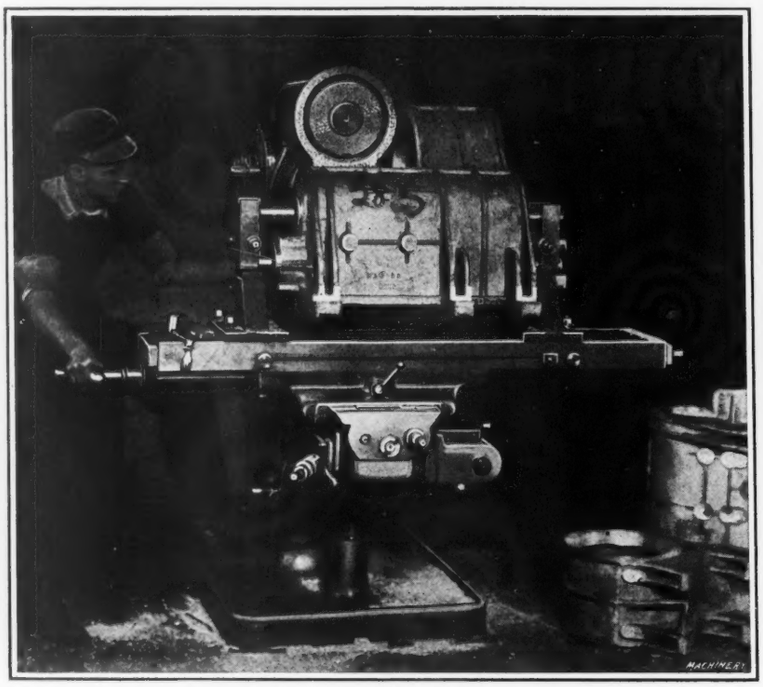
* * *

A COMMERCIAL AIRPLANE

A monoplane known as the *Butterfly* and said to be America's smallest flying craft, recently successfully completed its trial flight at College Point, Long Island. The *Butterfly* was developed by the L. W. F. Engineering Corporation to meet the requirements of civilians who desire a machine of low first cost and low operating expense. It is understood that the machine will be manufactured on the quantity production basis to sell at $2500. On its trial flight, the machine fulfilled all the predictions made for it by the engineers who had previously made wind tunnel tests of a model. The weight of the machine is 595 pounds, the maximum carrying capacity, 383 pounds, the wing span, 29 feet 9 inches, the length over all 19 feet, and the height over all 5 feet, 10 inches. The maximum speed, when in horizontal flight, is about 72 miles per hour, and the minimum speed at which the machine can be flown without loss of altitude is about 22 miles per hour. The climbing speed is 4800 feet in 10 minutes, and the radius of action 6 hours. The power plant, weighing 154 pounds, consists of a two-cylinder horizontally opposed, four-cycle, air-cooled, valve-in-head motor which develops 72 horsepower running at 1825 revolutions per minute.

SPOT-FACING ALUMINUM GEAR-CASES

In the Cotta Transmission Co.'s plant at Rockford, Ill., No. 2 single-pulley-driven Rockford millers are employed for the performance of spot-facing operations on aluminum gear-cases. The accompanying illustration shows one of these cases set up on the machine and there is a second case standing on the floor, which shows the six surfaces that have been spot-faced. From the illustration, it will be apparent that the fixture is of quite simple design, consisting of two arbors which support the work. These arbors are furnished with collars of suitable size to enter holes that have already been finish-bored. The two arbors are supported at either end by brackets bolted to the milling table, the arbors being held in place in the V-notches in the brackets by means of two straps. Obviously an end-mill is employed for the performance of this work, the cutter being 9 inches in diameter and driven at a speed of 300 revolutions per minute. On this job the six faces on a gear-case can be spot-faced in two minutes.



Rockford No. 2 Miller used for spot-facing Gear-cases

* * *

THE INCREASING USE OF STEEL PIPE

According to an editorial in the *American Metal Market and Daily Iron and Steel Report* reprinted in the National Tube Co.'s *Bulletin* for December, the production of wrought iron pipe decreased from 276,000 tons in 1913 to 203,000 tons in 1918, while the production of steel pipe increased from 1,969,000 tons in 1913 to 2,087,000 tons in 1918. The statistics covering pipe production do not give any data prior to 1913, but figures are available showing the skelp production as far back as 1905. From these statistics it is evident that from 1905 to 1918 there was an almost continuous decline in the tonnage output of iron skelp while there was a very large increase in the production of steel skelp. The decline in the iron skelp was from 453,000 tons in 1905 to 258,000 tons in 1918; while the increase in steel skelp was from 983,000 tons in 1905 to 2,305,000 tons in 1918.

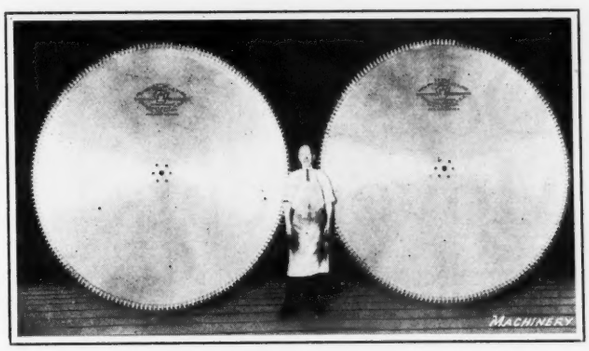
* * *

RESOLUTION IN FAVOR OF BUREAU OF FOREIGN AND DOMESTIC COMMERCE

At the convention of the Material Handling Machinery Manufacturers Association, held at the Waldorf-Astoria Hotel, New York City, February 26 and 27, a resolution was adopted to the effect that the expanding commerce and industry of the United States demands the support to the industry furnished through the instrumentality of the Bureau of Foreign and Domestic Commerce and that Congress therefore must be urged to appropriate the sum of $1,900,000 originally applied for by the Department of Commerce for this service to the industry.

THE LARGEST SAWS EVER MADE

What are believed to be two of the largest circular saws ever made have been completed by Henry Disston & Sons, Inc., of Philadelphia, Pa. They are of the spiral inserted-tooth type and are to be used by a well-known concern in the West for cutting shingle-blocks from the large trees of that section. Each of the saws shown in the accompanying illustration measures 108 inches in diameter and has 190 teeth inserted in the rim. Some idea of the great size of these saws may be had by comparing them with a 54-inch saw which is usually thought of as a large saw. The regular 54-inch saw is made from an ingot of steel weighing approximately 180 pounds, and its weight when finished is about



Circular Saws 108 Inches in Diameter for cutting Shingle-blocks

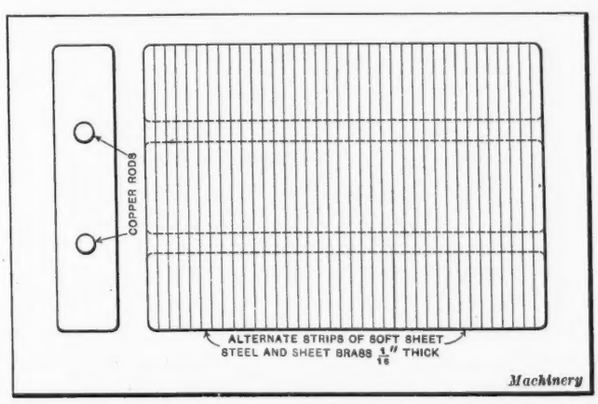
125 pounds. The 108-inch saw requires an ingot weighing 1140 pounds, which after reheating, rolling, and trimming, weighs about 795 pounds. The quality of steel and workmanship required in making these saws may be more fully realized when it is known that the teeth must travel at a speed of 130 miles per hour when the saw is in operation.

* * *

AUXILIARY MAGNETIC CHUCK

By JOHN LeLASH

As the holding surfaces of magnetic chucks become uneven through wear, frequent grindings are necessary to maintain accuracy if the chucks are used continuously. When small work must be ground to within very accurate limits a small auxiliary chuck, such as here illustrated, is of great advantage, as its surface can be trued up more quickly than that of the main chuck. The use of such an



Magnetic Chuck for Use when grinding Small Flat Work

auxiliary chuck will also prolong the life of the regular chuck as well as provide a means of holding small work to better advantage. The chuck shown is constructed from strips of soft sheet steel and sheet brass, 1/16 inch thick, alternately arranged and riveted together by two 5/16 inch copper rivets. Such a chuck about 4 inches long, 2½ inches wide and ¾ inch thick will be found a convenient size.

GERMAN MACHINE TOOL INDUSTRY

First-hand information obtained from Germany at a recent date indicates that a number of the new machine tool plants in Germany that sprang up during the war, appear to have either given up manufacturing or to have largely limited their production, owing to the present difficulties in obtaining materials and the high cost of labor. While the machine tool building business in Germany was profitable during the war, the numerous increases in labor costs and in the cost of materials since the armistice have largely swallowed up the profits of the past. Many machine tool builders and manufacturers of general machinery, noting the increases in the prices of machine tools, began to act as dealers, purchasing machine tools apparently for their own requirements, and then reselling them later at the higher prices, either for domestic consumption or for export. The iron and steel industries have made large profits since the armistice and have also secured controlling interests in a great many machine tool building firms. Recently, there have been a great many mergers of machine tool firms with manufacturers in other machine building lines, some of the larger and better known companies having absorbed the smaller concerns.

In spite of the difficulties with material and labor, a recent letter from Germany indicates that in the early part of March the machine tool industry there was exceptionally busy. The factories had so many orders on hand that many of them refused to accept new orders until the end of the present year. The low exchange rate is favorable for export, and almost all of the machine tool builders are working for the export trade. The price for medium-sized machine tools, expressed in marks, is forty times the price previous to the war, and hence, even in foreign currency, these machine tools command a price which is becoming nearly equal to the prices in the world's markets. The present prices of machine tools are prohibitive as far as the domestic market in Germany is concerned, and the re-equipping of German factories cannot be thought of by manufacturers, as the expense would necessitate such a large investment that reasonable returns on this investment would be improbable if not impossible.

* * *

INCREASE IN BRITISH EXPORTS

The recent efforts to stimulate the export trade of Great Britain to assist in righting the exchange position are indicated in the Board of Trade figures for January. These figures show that the exports, for the first time on record, totaled more than £100,000,000, or, in exact terms, £105,879,000, this being an increase of £58,000,000 over January of last year. Exports of manufactured articles increased 100 per cent, including an advance of £15,000,000 in cotton textiles, £6,000,000 in woolens and £4,000,000 in iron and steel products. While imports were still large, totaling £183,000,000, or £48,000,000 over January of last year, these were largely essential products, such as food imports which showed an increase of £18,000,000 and raw cotton, which increased £22,000,000.

* * *

PLANS FOR AMERICAN FOUNDRYMEN'S CONVENTION

The American Foundrymen's Association has decided to hold its 1920 annual convention and exhibit during the week beginning October 4, at Columbus, Ohio. The exhibition buildings on the Ohio state exposition grounds at Columbus afford the most extensive and best accommodations that have ever been provided for the display of foundry, machine shop, and metal-working equipment at any of the association's conventions. The adjoining buildings provide the necessary lecture and meeting rooms. This arrangement will make it possible to hold all of the activities of the convention in one place.

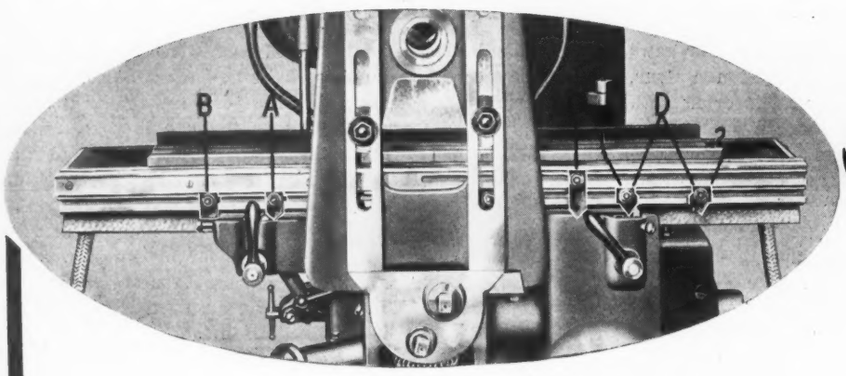


Table Dogs Control All Movements

There are only four different style dogs necessary to operate all the automatic controls of the machine; for all ordinary milling operations two or three of the styles are usually sufficient.

A long dog used at "A" or "B" controls the reversing of the table and may also be used for stopping same. When the table is moving at its constant fast travel a short dog "B" is employed for stopping the table.

Dog "C" controls the constant fast travel and may be set to operate in either direction.

Dogs "D" control the variable feed and may be set to operate in either direction; arrangement 1 when moving to the right—arrangement 2 when moving to the left.

The table always moves at its constant fast travel when reversed.

When the machine is set for reversing the spindle, the spindle is reversed when the table is reversed. When the machine is set for stopping the spindle, the spindle stops when the table is reversed and starts with the variable feed. No extra tripping dogs are required for either reversing or stopping.

Continuous milling operations may be performed by employing two "A" dogs and two "D" dogs.

Intermittent milling operations may be performed by employing dogs "A" and "B" and several pairs of dogs "C" and "D", depending upon the number of pieces of work on the table.

Brown & Sharpe Mfg. Co., Providence, R. I.

BROWN & SHARPE No. 21

A New Machine for Greater Production

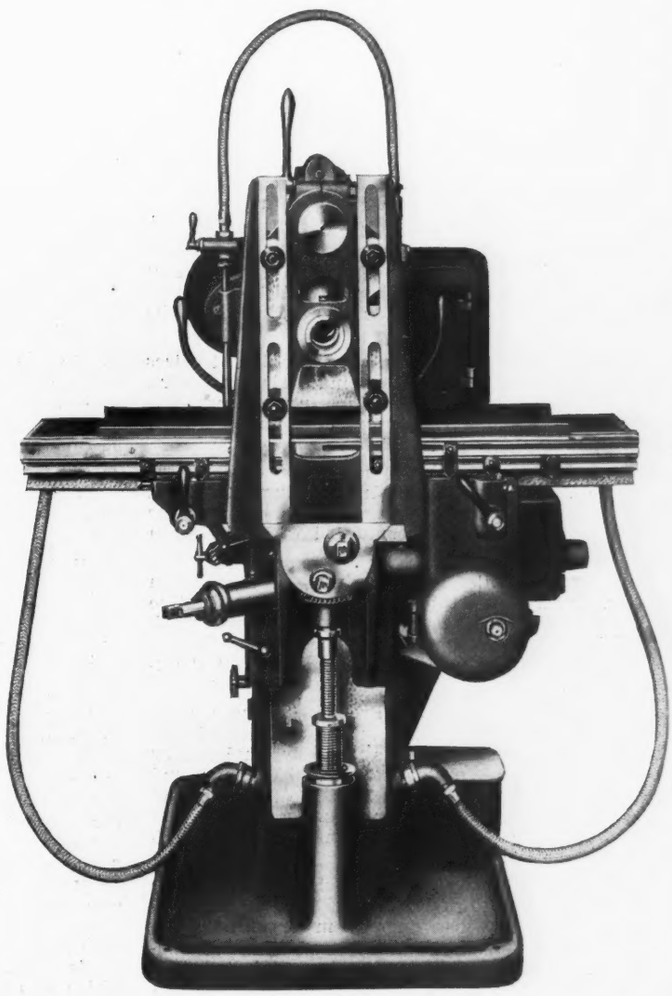
All Movements of Table and Spindle Entirely Automatic

These Movements, or Combination of Movements are Controlled by the Table Dogs, and include—

TABLE { Variable Feed / Constant Fast Travel / Stop

SPINDLE { Start / Right Hand / Left Hand / Stop

Table and spindle may be operated independently of each other. These movements may or may not be intermittent in either or both directions and may take place one or more times.



Automatic Milling Machine

PERSONALS

HARRY C. O'NEILL, for several years commercial agent with the American Express Co. at Detroit, Mich., has recently become associated with the J. R. Stone Tool & Supply Co., of Detroit.

K. J. EVANS, of Joseph T. Ryerson & Son, Chicago, was elected a member of the publicity committee of the Engineering Advertisers' Association at the annual meeting, March 9.

R. W. ELLINGHAM, formerly works manager of the Heald Machine Co., Worcester, Mass., is now associated with the Van Norman Machine Tool Co., Springfield, Mass., in a similar capacity.

EARLE M. PORTER, formerly tool efficiency engineer of the Willys-Overland Co., Toledo, Ohio, has been appointed mechanical engineer of the Giern & Anholtt Tool Works, Inc., Detroit, Mich.

E. KENNEDY, formerly with the Chicago branch of Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, has been transferred to the Buffalo office to fill the vacancy made by the death of F. C. Meyer.

R. M. CARTER, for seven years connected with the Gisholt Machine Co. of Madison, Wis., is now manager of sales for the Giddings & Lewis Mfg. Co., Fond Du Lac, Wis., manufacturer of horizontal boring machines.

J. B. SMYTHE, formerly superintendent of A. O. Norton, Ltd., Coaticook, Quebec, Canada, is now general manager of the new office of the George F. Foss Machinery & Supply Co. at 174 Lafayette St., New York City.

W. S. RUGG, manager of the railway and marine departments of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., and CHARLES ROBBINS, assistant sales manager, have been made assistants to the vice-president.

S. F. WALL, formerly secretary and treasurer of the Michigan Tool Co., 268 E. Jefferson Ave., Detroit, Mich., and T. M. OLSON, manager, have become associated with the Continental Tool Works of Detroit, which was recently organized.

H. W. CLARK, of the Chicago Pneumatic Tool Co., Chicago, Ill., was elected chairman of the membership committee at the annual meeting of the Engineering Advertisers' Association of Chicago, March 9. Mr. Clark is also a director of the association.

CHARLES M. MANLY and C. B. VEAL have established offices at 250 W. 54th St., New York City, as industrial engineers, specializing in the coordination of engineering and manufacturing requirements in the design, production, and operation of automotive power plants and vehicles.

EDWARD F. BUIE has been appointed Pacific coast representative of the Victor Saw Works, Inc., Springfield, Mass., to succeed Victor Pezzini, who has gone into business for himself. Mr. Buie was formerly connected with the Union Hardware & Metal Co. of Los Angeles, Cal.

J. M. COOK, formerly sales representative for the Norton Co., Worcester, Mass., is now sales and service representative of the Waltham Grinding Wheel Co.'s line of abrasive products, and will be located in the general offices of the Republic Tool & Mfg. Co., selling agent for the company, at Cleveland, Ohio.

W. E. FINKBEINER has joined the Production Engineering Co., 212 Center St., New York City, in the capacity of consulting engineer. Mr. Finkbeiner was formerly employed by Edison & Co., Orange, N. J., as toolmaker, tool foreman, and superintendent. He is a specialist in the designing and building of automatic machinery, plant reorganization, plant appraisal, etc., and has been engaged in consulting engineering work for the last fifteen years.

GEORGE T. CHAPMAN, formerly chief designer and master mechanic of the Flaxen Fibre-Down Co., Inc., North Tonawanda, N. Y., has been instrumental in organizing the Frontier Engineering Co. of North Tonawanda. Mr. Chapman, besides being chief designing engineer of the company, will also maintain an engineering office in Buffalo for the purpose of designing automatic labor-saving machinery and equipment, tools, jigs, and fixtures.

W. J. ELLIOTT, formerly manager of the St. Catharines factory of the Whitman & Barnes Mfg. Co., St. Catharines, Ontario, Canada, has recently been elected vice-president of the company and will have entire charge of the Canadian division of the business, both selling and manufacturing. Mr. Elliott has been connected with the company for twenty-seven years; advancement from one position of importance and responsibility to another was rapid, until in January 1908 he was made manager.

RAY T. MIDDLETON, formerly general sales manager of the Standard Steel Castings Co., Cleveland, Ohio, has become vice-president and director of sales and advertising of the Kelly Metals Co. of Chicago, Detroit, and Los Angeles. Mr. Middleton's headquarters will be in Chicago, where the principal production plant of the company will be established in the near future. The company will continue its present plants in Detroit and Los Angeles and expects to establish a third branch plant at a point in the East.

OBITUARIES

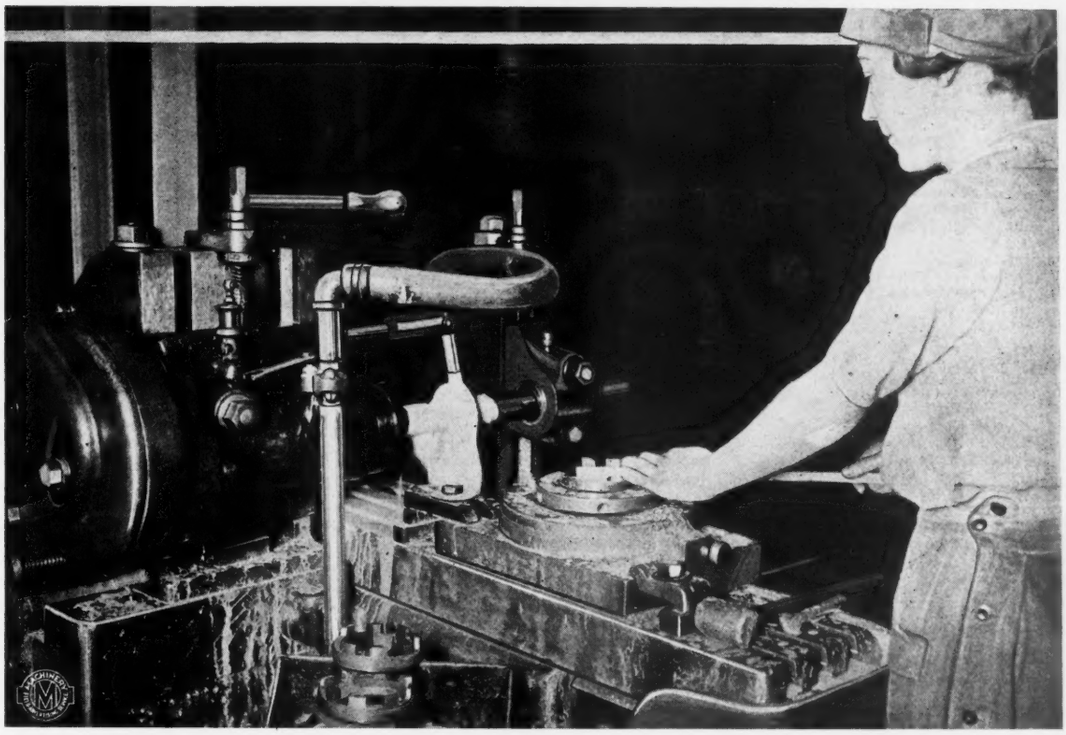
ARTHUR WILZIN, for more than twenty years director of the E. W. Bliss Co.'s Paris works, died of pneumonia, January 2, in his fifty-ninth year, at Nice, France. Mr. Wilzin was sent to France in 1889 to take charge of the E. W. Bliss Co.'s exhibit at the Universal Exhibition. He remained there as selling agent for the company, and from the sales office of which he was in charge developed the present extensive French works of the company at Saint-Ouen, near Paris, where about 500 people are at present employed. Mr. Wilzin developed the Wilzin process for flat ware manufacture and invented several types of presses.

MELVIN B. NEWCOMB, chief engineer of the rubber machinery department of the Wellman-Seaver-Morgan Co., E. 70th St. and Central Ave., Cleveland, Ohio, died March 13 at his home in Akron, Ohio, aged thirty-one years. Mr. Newcomb was born in Bridgeton, N. J. He studied mechanical engineering at the University of Wisconsin, and was engaged in engineering work with the I. P. Morris Co., Philadelphia, Pa.; Allis Chalmers Mfg. Co., Milwaukee, Wis.; Wisconsin Engine Co., Corliss, Wis.; and the Firestone Tire & Rubber Co., Akron, Ohio. In January, 1918, he joined the hydraulic turbine engineering department of the Wellman-Seaver-Morgan Co., and a few months later was appointed to the position which he held at the time of his death.

JOHN JEPPSON, superintendent and one of the founders of the Norton Co., Worcester, Mass., died on March 26 in Havana, Cuba, where he had gone for a rest. Mr. Jeppson was born in Sweden in 1844 and came to this country at the age of twenty-four. Soon after he landed, he went to Worcester and became affiliated with F. B. Norton, who was then engaged in the pottery trade, from which developed the grinding machine and grinding wheel business now known as the Norton Co. In 1885, he was taken into the company, which was then called the Norton Emery Wheel Co. He designed much of the machinery used in making the grinding wheels and took an active part in the management of the company until about seven years ago, from which time he served merely in an advisory capacity. Mr. Jeppson is survived by his wife and one son, George N. Jeppson, who is the present works manager of the Norton Co.

ANTOINE T. LANGELIER, treasurer of the Langelier Mfg. Co., Cranston, R. I., died at his home in Cranston, March 1. Mr. Langelier was born in St. Hyacinth, Quebec, Canada, in 1834. His early life was spent in Canada, and he completed his education at the St. Hyacinth College, from which he graduated in 1852. He moved to Concord, N. H., in 1869, and while there perfected his inventions for car coupling. In 1882, Mr. Langelier went to Providence where, with his son, he established the Langelier Mfg. Co., designers and builders of special machinery and tools. From a small beginning the business grew until, in 1917, it became necessary to build a larger plant, and the firm moved from Providence to Cranston. Mr. Langelier held the position of treasurer until the time of his death, and took an active part in the business up to about four years ago. He is survived by one son, Antoine J. Langelier, president and general manager of the Langelier Mfg. Co., and two daughters.

JOHN N. DERBY, first vice-president of Manning, Maxwell & Moore, Inc., of New York, died suddenly of heart disease on March 28, at his home in Port Chester, N. Y. Mr. Derby was born in Saginaw, Mich., and was in his fifty-fourth year. He was a graduate of the University of Michigan. His business career began in the state where he was born, and there he developed the Metropolitan injector, the manufacture of which was begun in 1888 by the Hayden & Derby Mfg. Co. About thirty years ago Mr. Derby became identified with Manning, Maxwell & Moore, and has been associated with that firm ever since, at first in connection with their steam specialties and later in charge of the sales of the Ashcroft Mfg. Co., the Consolidated Valve Co. and the United Injector Co. having plants at Bridgeport and Boston. The Hayden & Derby Mfg. Co. was absorbed by the United Injector Co. when the Hancock Inspirator Co. was taken over. In addition to being vice-president, Mr. Derby was a member of the executive committee of Manning, Maxwell & Moore, Inc., and lately devoted his attention to the railroad trade. Mr. Derby leaves a wife, two daughters and a son.



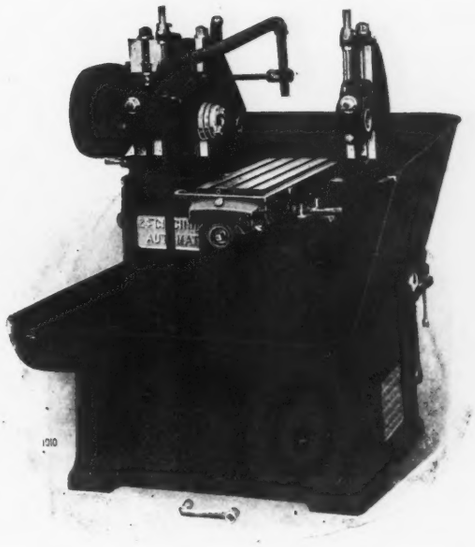
Cincinnati Automatic Millers

May Be the Solution of Your Production Problems

QUANTITY production of duplicate parts with the Cincinnati Automatic Miller is merely a matter of routine. One operator can attend a battery of machines, and girls are readily trained to do the work.

The photograph—taken by courtesy of the Autocar Co., Ardmore, Pa.—illustrates the milling of eight slots in the edge of malleable iron bearing retainers. Eac' slot is ¾″ wide, 7/16″ deep, the wall of the casting being 5/16″ thick.

Write us for production figures on this sort of work.



THE CINCINNATI MILLING MACHINE COMPANY

CINCINNATI **OHIO, U. S. A.**

COMING EVENTS

April 19-22—Convention of the National Metal Trades Association at New York City; headquarters, Hotel Astor. Secretary, Homer D. Sayre, Peoples Gas Bldg., Chicago, Ill.

April 29—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137 Sibley Block, 328 Main St. E., Rochester, N. Y. Secretary, O. L. Angevine, Jr., 547 Arnett Blvd., Rochester, N. Y.

April 29-May 1—Annual convention of the American Gear Manufacturers Association at Detroit, Mich.; headquarters, Hotel Statler. Secretary, F. D. Hamlin, 4401 Germantown Ave., Philadelphia, Pa.

May 12-15—Seventh national foreign trade convention in San Francisco, Cal. Secretary of the National Foreign Trade Council, O. K. Davis, 1 Hanover Square, New York City.

May 17-19—Joint meeting of the American Supply & Machinery Manufacturers' Association, the Southern Supply & Machinery Dealers' Association, and the National Supply & Machinery Dealers' Association at Atlantic City, N. J.; headquarters, Hotel Marlborough-Blenheim.

May 20-21—Spring convention of the National Machine Tool Builders' Association at Atlantic City, N. J.; headquarters, Hotel Traymore, Secretary, Charles E. Hildreth, Worcester, Mass.

May 24-27—Spring convention of the American Society of Mechanical Engineers at St. Louis, Mo.; headquarters, Hotel Statler. Secretary, Calvin W. Rice, 29 W. 39th St., New York City.

June 21-26—Annual meeting of the American Society for Testing Materials at Asbury Park, N. J.; headquarters, New Monterey Hotel. Secretary and treasurer, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

October 4-9—Annual convention and exhibit of the American Foundrymen's Association at Columbus, Ohio.

SOCIETIES, SCHOOLS AND COLLEGES

Clarkson College of Technology, Potsdam, N. Y. Catalogue for 1920 which contains calendar for 1919—1920, courses of study, and other information relating to the college.

Engineering Advertisers' Association of Chicago held its annual meeting March 9 at the Auditorium Hotel, electing the following officers: President, A. H. Hopkins; vice-president, J. J. Arnsfield; secretary, G. S. Hamilton; and treasurer, E. I. Pratt.

BOOKS AND PAMPHLETS

Heat-treatment of Duralumin. By P. D. Merica, R. G. Waltenberg, and H. Scott. 46 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Scientific Paper No. 347 of the Bureau of Standards. Price, 10 cents.

Use of Modified Rosenhain Furnace for Thermal Analysis. By H. Scott and J. R. Freeman, Jr. 7 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C. as Scientific Paper No. 348 of the Bureau of Standards. Price, 5 cents.

A Study of the Deterioration of Nickel Spark-plug Electrodes in Service. By Henry S. Rawdon and A. I. Krynitzky. 16 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C. as Technologic Paper No. 143 of the Bureau of Standards. Price, 10 cents.

Constitution and Metallography of Aluminum and its Light Alloys with Copper and with Magnesium. By P. D. Merica, R. G. Waltenberg and J. R. Freeman, Jr. 14 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Scientific Paper No. 337 of the Bureau of Standards. Price, 10 cents.

Mechanical World Year Book—1920. 328 pages, 4 by 6¼ inches. Published by Emmott & Co., Ltd., 65 King St., Manchester, England. Price, 2 shillings, net.

This is the thirty-third year of publication of this reference book for mechanical engineers, and considerable new material has been added to the present edition. There is a new section dealing with water and hydraulic work, in which much information is given on the friction of water in pipes, and on pumps and pump fittings. The applications of hydraulic power are described, and particulars are given of hydraulic accumulators, hydraulic press cylinders, flanging presses, punching presses, hydraulic pipes, flanges, etc. Another new section is that on "Heating and Evaporating Liquids," which describes tubular heaters, feed-water heaters, and evaporators, as well as details of pipes and fittings. Additions have been made to the section on compressed air, and to the screw thread tables.

American Machinists' Handbook. By Fred H. Colvin and Frank A. Stanley. 758 pages, 4 by 6¾ inches. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $4, net.

This is the third edition of this reference book for the machine shop and drafting-room. Considerable new material has been added to bring the book up to date, the present edition containing seventy-seven more pages than the previous edition. The general arrangement of the book remains the same. The data given cover the following subjects: Screw Threads; Pipe and Pipe Threads; Twist Drills and Taps; Taps; Files; Work-benches; Soldering; Gearing; Milling and Milling Cutters; Cold Saws; Turning and Boring; Grinding and Lapping; Oilstones and their Uses; Screw Machine Tools, Speeds and Feeds; Punch Press Tools; Broaches and Broaching; Bolts, Nuts, and Screws; Miscellaneous Tables; Calipering and Fitting; Tapers and Dovetails; Shop and Drawing-room Standards; Miscellaneous Information; Wire Gages and Stock Weights; Horsepower, Belts, and Shafting; Steel and Other Metals; Steam Hammers and Drop-forging; Knots, Eye-bolts, Ropes, and Chains; General Reference Tables; Shop Trigonometry; and Dictionary of Shop Terms.

The Model T Ford Car. By Victor W. Page. 410 pages, 5 by 7 inches. Published by the Norman W. Henley Publishing Co., 2 W. 45th St., New York City. Price, $1.50.

The 1920 edition of this instruction book for drivers and owners of Ford cars has been thoroughly revised and considerably enlarged. The new matter covers the Fordson farm tractor, the F. A. starting and lighting system, and the worm-drive one-ton truck. All parts of the Ford Model T car and Fordson tractor are described and illustrated in a comprehensive manner. The construction is fully treated and the operating principles clearly described. Complete instructions for both driving and repairing are given. Practically no mechanical changes have been made in the Ford car mechanism for 1920, except the addition of an electrical starting and lighting system, which is fully described in Chapter VI; consequently the instructions given apply to the new models as well as to those that have preceded them. As many Ford owners fit various attachments to the chassis to convert it into a truck or tractor, a brief review of these converters is included in the new edition. The chapter heads are as follows: The Ford Car, its Parts and their Functions; the Engine and Auxiliary Groups; Details of the Ford Chassis Parts; Driving and Maintenance of Ford Cars; Overhauling and Repairing Mechanism; the Ford Tractor and Tractor Conversion Sets and Genuine Ford Tractor; Operation Maintenance of Fordson Tractor; Repairing and Using Fordson Tractor.

Design and Construction of Heat Engines. By William E. Ninde. 704 pages, 6 by 9 inches; illustrated. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $6, net.

The object of this book, as stated by the author in the preface, is to supply in one volume the material most essential to the well-equipped, independent designer of heat engines, and to give this material in the form most convenient for use in the classroom and in practice by a separate treatment of the different phases of the subject. The author has included in the contents material from his notebooks on engine design, covering his practice and observation for over twenty years, and the revisions and additions which were made to adapt the notes to his teaching work for the last ten years, as well as material from technical books and periodicals necessary to fill the gaps in first-hand information. In the derivation of formulas, abstruse methods have been avoided as much as possible, but it has been the aim to omit no important element which permits of practical treatment, and the formulas and fundamental principles have been arranged in a form suitable for direct application. The book is divided into six parts covering the Heat Engine; Thermodynamics; Friction and Lubrication; Power and Thrust; Mechanics; and Machine Design. The two appendixes give the moment of inertia of irregular sections, and a table of U. S. standard bolts and nuts. Steam tables and other tables found in all handbooks are omitted.

Graphic Production Control. By C. E. Knoeppel. 477 pages, 6 by 9 inches; illustrated. Published by the Engineering Magazine Co., 6 E. 39th St., New York City. Price, $10.

The publication of this book is timely in view of the fact that production (and means of increasing and controlling it) is one of the most prominent subjects under discussion today, and the matter here presented should in consequence be of considerable interest. The book outlines a system of controlling production by the use of charts and other graphic means, the purpose being to place before industrial executives a complete description of the mechanisms of graphic production control. The presentation has been arranged in five parts: Section I deals with the philosophic aspect of graphic production control, calling attention to the present need for production, the relation of management to production, the use of graphics in warfare and industry, the laws of graphic production control, as well as the fundamental considerations which must be recognized in the installation of this plan. Section II deals with the preliminary steps in organizing for the installation of graphic production control. Section III takes up the practical installation of the plan. Section IV treats of the managerial features of the system in its relation to organization, standardization, and costs, and the relation of graphics to the labor problem. Section V discusses the pitfalls and economic aspects of graphics in industry. The universal applicability of graphical methods is indicated by the fact that the material in the book is based on experience in the development and use of graphics in the following lines: Textile machinery; gas traction engines; gray iron castings; brass castings; steel castings; steel plate construction; metal furniture; automobile axles and transmissions; small motors; taps, dies, reamers, and gages; hardware; clothing; rubber tires and tubes; truck axles; oil producing and refining; fiber board; and automobiles.

Electric Furnaces in the Iron and Steel Industry. By W. Rodenhauser, J. Schoenawa, and C. H. Vom Baur. 460 pages, 6 by 9 inches. Published by John Wiley & Sons, 432 Fourth Ave., New York City. Price, $4.60, postpaid.

This book, which was originally published in German in 1911, is now in its third English edition, and the present volume has been entirely rewritten. The great strides made in all forms of industry during the war are also apparent in the development of the electric furnace and in its operation. This has made it necessary to revise this book in order to include the latest information on the design and construction of these furnaces and their use in the manufacture of steel and iron. The book is intended for the practical man, but it also explains the electric laws and phenomena involved and the scientific principles upon which the work rests. It states the principal laws which the construction and operation of electric furnaces entail without entering into long mathematical discussions, short arithmetical examples only being given, dealing with actual furnace problems. The types of furnaces most extensively used are described in detail. The book is divided into two parts, the first of which deals with questions relative to the construction of electric furnaces and the apparatus used, while the second part takes up the practical use of these furnaces in the steel mill, treating of the materials for furnace construction and costs of operation, as well as the electro-metallurgy of iron and steel. The chapter heads are as follows: Historical; Some Laws and Fundamental Principles of Electricity; Effects of the Electric Current; Power Factor and Alternating Current Theory in General; General Conditions for the Operation of Electric Furnaces; The Arc Furnaces in General; the Stassano Furnace; the Heroult Furnace; the Girod Furnace; the Rennerfelt Furnace; the Induction Furnace in General; the Kjellin Furnace; the Rochling-Rodenhauser Furnace; the Electric Shaft Furnace; General Review; Final Considerations; Materials for Furnace Construction; the Costs of Operation; the Electric Smelting of Iron Ores with the Production of Iron and Steel; and the Use of the Electric Furnace for Melting, for the Refining of Pig Iron, and for the Production of Ordinary and Special Quality Steel.

NEW CATALOGUES AND CIRCULARS

Henry G. Thompson & Son Co., New Haven, Conn. Price list of Milford hacksaw blades and band saws.

Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill. Circular advertising Link-Belt roller chain for driving power farm machinery.

National Machinery Co., Tiffin, Ohio. National Forging Machine Talk No. 37, describing the making of pipe couplings on the forging machine without welds.

Saint Louis Machine Tool Co., 932 Loughborough Ave., St. Louis, Mo. Pamphlet illustrating and giving specifications for the No. 7 Saint Louis polishing machine.

Cashman Tool Co., Waynesboro, Pa. Catalogue A, illustrating and describing Cashman adjustable shell reamers. Tables are given, listing the sizes, number of blades, and prices.

F. C. Brand & Co., 27 Warren St., New York City. Circular advertising white metal pattern letters and figures for the use of foundrymen, machinists, and patternmakers.

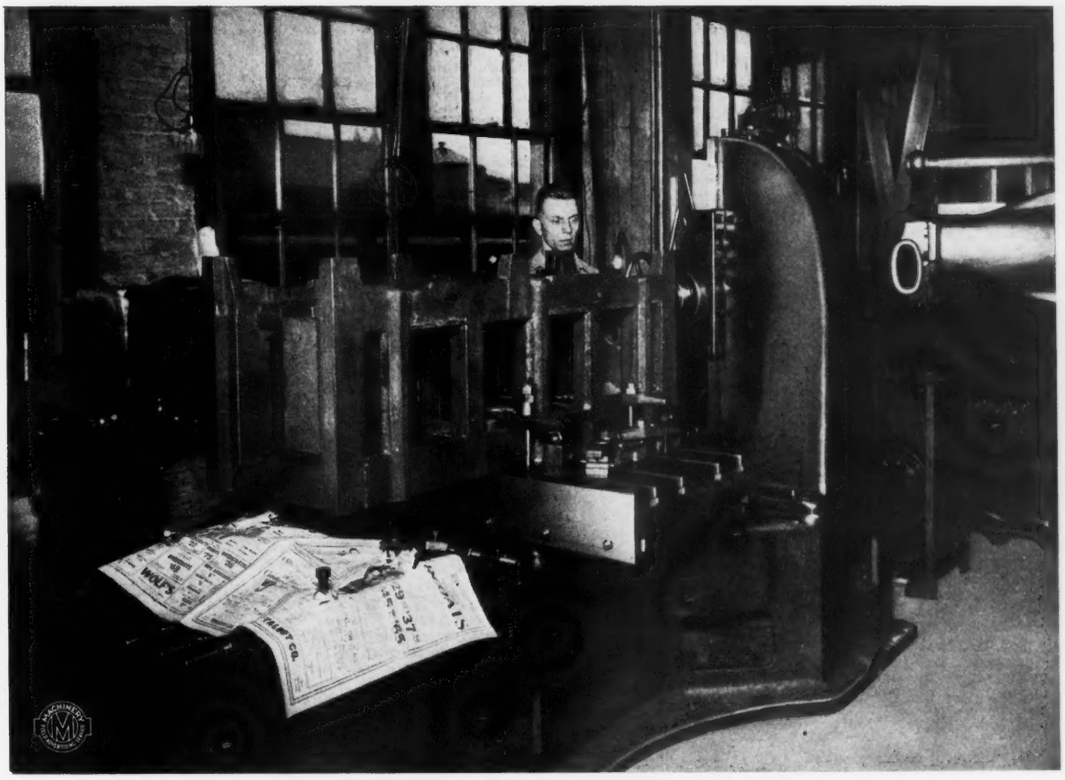
Hooven, Owens, Rentschler Co., Hamilton, Ohio. Catalogue treating of Hamilton Corliss rolling mill and blowing engines, and their application in the iron and steel industry.

E. M. Dart Mfg. Co., Providence, R. I. Catalogue M, giving dimensions and prices of Dart union fittings and flanges. Copies of the catalogue will be sent upon request.

Nice Ball Bearing Co., Nicetown, Philadelphia, Pa., is issuing a monthly publication entitled "Nice News," published by and in the interests of the employes of the company.

New Departure Mfg. Co., Bristol, Conn. Loose-leaf circulars 126 FE, 127 FE, and 128 FE, illustrating installations of ball bearings in die forming machines, band saws, and planers.

LUCAS "PRECISION" BORING MACHINES



Fine Machines In a Fine Shop

For more than three years, two Lucas "Precision" Boring Machines have been used exclusively for jig work by John Bath of Worcester—builder of fine tools. One of these machines is here shown boring holes in a very heavy box jig—so long that the end supports of the machine had to be removed to accommodate it.

There are 42 holes in the body of this jig and 29 in the cover—a total of 71—and diameters vary from 5/8" to 2". All must be correctly located—diameters and center distances being held to plus and minus limits of 0.0005".

Work of this kind is nothing unusual for these machines.

ASK FOR COMPLETE DESCRIPTION

LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry, Societe Anonyme, Alfred Herbert, Paris. Societe Anonyme Belge, Alfred Herbert, Brussels. Allied Machinery Co., Turin, Barcelona, Zurich. Benson Bros., Sydney, Melbourne. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Rotterdam. Andrews & George Co., Tokyo.

William H. Haskell Mfg. Co., Pawtucket, R. I. Catalogue D, giving dimensions and price lists of this company's line of bolts, screws, studs, nuts, punchings, and screw machine products.

Wagner Electric Mfg. Co., St. Louis, Mo. Bulletin No. 122, describing the construction and application of Wagner polyphase motors, of the squirrel-cage and wound-rotor or slip-ring types.

Cisco Machine Tool Co., Cincinnati, Ohio. Catalogue covering the line of Cisco lathes, which are made in belt- and motor-driven styles, with either plain or geared head in sizes from 12 to 26 inches.

Carlyle Johnson Machine Co., Manchester, Conn. Catalogue of Johnson friction clutches, showing types of machines on which this clutch has been successfully applied, which includes all classes of machine tools.

Electric Controller & Mfg. Co., Cleveland, Ohio. Bulletin 1037 B, giving dimensions and other data for Type B limit stops for direct-current motors, applicable to electric cranes or other motor-driven machines which must be stopped automatically.

Production Engineering Co., 212 Center St., New York City. Circular entitled "Prenco Tools, Dies, and Fixtures," outlining "Prenco" tool service and containing a synopsis of the personnel of the company and the method of handling work.

Nickle Engineering Works, Saginaw, Mich. Bulletin 1-C entitled "Agitator Driving Yokes," describing a standard power transmission device, made in several styles and sizes, for driving agitator or stirrer shafts in chemical tanks and kettles.

Walter A. Zelnicker Supply Co., St. Louis, Mo. Bulletin 278, containing a list of new and second-hand rails, cars, tanks, heavy machinery, and equipment used in operating and maintaining railroads, power plants, mines, and industrial plants of all kinds.

H. H. Arnold Co., Rockland, Mass. Circular giving prices and dimensions of Arnold shell reamers, chucking reamers, hand reamers, counterbores, and side milling cutters. These tools are made with high-speed steel blades, brazed to low-carbon steel bodies.

Geometric Tool Co., New Haven, Conn., has published a book to serve as a memorial to the employes of the company who enlisted in the service of the Government during the war. The book contains portraits of the men and a brief outline of their records in service.

Griscom-Russell Co., 90 West St., New York City. Bulletin 1120, descriptive of the construction and operation of the Stratton Jr. oil separator. Bulletin 311, illustrating and describing the Reilly evaporator, of the submerged type, for use in marine and stationary power plants.

Seneca Falls Mfg. Co., Inc., 381 Fall St., Seneca Falls, N. Y. Catalogue 27, illustrating and describing the "Star" screw-cutting engine lathes, which are made in 9-, 11-, 12-, and 13-inch sizes, for belt or motor drive. The various attachments for use on these lathes are also illustrated and described.

Gale-Sawyer Co., South Weymouth, Mass. Catalogue 3, giving dimensions, prices, and other data for the line of small tools manufactured by the company, which includes end-mills, T-slot cutters, side milling cutters, etc. The catalogue also gives tables of cutting speeds, and weights of round bars of high-speed steel and carbon steel.

Ingersoll Milling Machine Co., Rockford, Ill. Bulletin 39, illustrating the line of continuous milling machines made by the company for high-quantity production on special classes of work. The machines shown include the differential type, drum type, rotary and circular table machines, reciprocating type, and semi-automatic machines.

Wilton Tool & Mfg. Co., 84 Linden Park St., Boston, Mass. Booklet entitled "A Message of Measurements," by H. L. Van Keuren, describing the use of Wilton master gage-blocks, which are made to an accuracy of 0.000010 inch. These sets of gage-blocks can be assembled into built-up combinations which will be accurate to 0.0001 inch.

Cutler-Hammer Mfg. Co., Milwaukee, Wis. Loose-leaf bulletins giving ampere ratings of direct- and alternating-current motors, and price lists, dimensions, etc., for automatic starters, elevator reversing switches, elevator controllers, gage-type pressure regulators, push-button master switches, limit switches, brake magnets, speed regulators, etc.

Duke Steel Co., 191 Pearl St., New York City. Catalogue containing tables of weights, dimensions, and price lists of "Duranium" high-speed steel, and Duke high-speed and tungsten steel, in bars, billets, blocks, disks, rings, and special shapes. The heat-treatment employed for each of the various brands of tool and alloy steel made by the company is described.

R. K. LeBlond Machine Tool Co., Cincinnati, Ohio. Catalogue describing the construction and operation of the LeBlond "Multi-cut" lathe, which is built in two sizes—6 inches swing, with 10 inches capacity between centers, and 9 inches swing with 16 inches capacity between centers. The catalogue also shows typical tool lay-outs for jobs performed on these machines.

Heald Machine Co., Worcester, Mass., is now issuing a series of pamphlets on the Heald magnetic chuck, the first of which shows various applications on lathes, planers, millers, and grinders; the second describes the features of these chucks, treating of the holding power, unit construction, magnetism, waterproof and oilproof properties, etc.; and the third contains specifications and prices.

Greenfield Tap & Die Corporation, Greenfield, Mass., manufacturer of tools for cutting and gaging screw threads, is issuing a new publication entitled "The GTD Helix." The company has been publishing an employes' edition for two years, but now thinks it desirable to make the distribution more general. Besides the editorials, there is a section devoted to dealers' service, which should be of interest to the trade.

Esterline Co., Indianapolis, Ind. Bulletin 395, treating of power factor recording instruments. The book points out the evils of low power factor on the central station, the isolated plant and the power customer, and tells how to locate and eliminate the causes of low power factor. The Esterline power factor recorders are illustrated and described. Copies of the bulletin will be sent to any engineer interested in power factor problems.

H. B. Underwood Corporation, Philadelphia, Pa. Catalogue of portable tools for use in railway repair and machine shops. Among the tools illustrated and described are cylinder and valve-seat boring-bars, boring-bars for turbine engines, boring-bars for lathe work, and other special types of boring-bars, facing arms, planer tools, flue cleaners, crankpin turning machines, milling machines, pipe-bending and straightening machines, etc.

Greenfield Machine Co., Greenfield, Mass. Catalogue 7, illustrating and describing Greenfield universal grinders for tool, cutter, and general machine shop grinding. The catalogue contains views showing the variety of operations for which these machines are adapted, which include cutter grinding, internal grinding, grinding flutes of taps, cylindrical grinding, flat and beveled work, form grinding, and surface grinding. Special attention is called to the new No. 2 universal grinder, which is an improved design.

Detroit Hexagon Drill Co., 27-29 Woodward Ave., Detroit, Mich. Booklet entitled "Cutting the Corners," describing the drills made by this company for cutting hexagon or square holes. These tools, which are known as the "Detroit Hex" drills, will drill square or hexagon holes in steel, iron, brass, aluminum, micarta, bakelite, wood, marble, etc. They can be used in any drilling machine, screw machine, milling machine, or lathe, and may be operated at speeds up to 400 revolutions per minute.

Wheeler Condenser & Engineering Co., Carteret, N. J., has issued the fifth edition of its handbook "Steam Tables for Condenser Work." The book gives the properties of saturated steam from 29.8 inches vacuum to atmospheric pressure in increments of tenths of an inch. A complete table is given of the properties of saturated steam above atmospheric pressure. The book also tells how to make measurements by means of the mercury column and barometer, and gives constants and tables for making corrections in readings.

Golden Co., 405 Lexington Ave., New York City. Catalogue 230, describing a high-precision micrometer made by the Societe Genevoise d'Instruments de Physique of Geneva, Switzerland, measuring 100 millimeters to 0.001 millimeter, or 4 inches to 0.00005 inch. Catalogue 239, illustrating and describing test comparators made by the Societe Genevoise d'Instruments de Physique for making comparisons to an accuracy of 0.001 millimeter or 0.00005 inch. The comparators are shown in use measuring balls, disks, cylinders, and rings.

Gould & Eberhardt, Newark, N. J. Bulletin 45, illustrating Gould & Eberhardt automatic gear-cutting machines, designed especially for intensive production on automotive gears. The line includes vertical gear-cutting machines, continuous-ring gear-cutting machines, four-spindle bevel gear roughing shapers, worm-wheel generating machines, worm roughing machines, continuous cam milling machines, and multiple-spindle hobbing machines. Views are shown illustrating installations of the various types of machines at work in a number of large automobile and gear-cutting plants.

Gisholt Machine Co., 9 S. Baldwin St., Madison, Wis. Circular entitled "Machining Parts Economically," illustrating the Gisholt standard turret lathe, which is built in six sizes, ranging from 13 to 41 inches swing, and is adapted for boring, turning, facing, and thread-cutting of parts made from cast iron, steel castings, steel forgings, and bronze or malleable iron. Circular entitled "Gisholt Method of Tool Grinding," illustrating the Gisholt universal tool grinder, which is adapted for grinding all kinds of tools, including bent tools, inserted cutters and small tool bits, as well as larger tools.

Boston Gear Works, Norfolk Downs (Quincy), Mass. Catalogue F-10, containing a complete list of the standardized gears carried in stock by this company. The line comprises 1200 sizes, including the standard styles of spur, bevel, miter, spiral, and helical gears, worm-gears and worms, sprockets, pinion wire, and rack in brass, iron, and steel. This catalogue shows a new line of hardened steel spiral and worm gears, with the threads ground and with extra long faces, as well as some new sizes of thrust ball bearings for small size shafts. Copies of the booklet will be sent upon request.

Hyatt Roller Bearing Co., 1 Madison Ave., New York City. Circular entitled "A Vision Realized," advertising the use of Hyatt roller bearings in industrial plants, mining apparatus, machinery of all kinds, motor cars, trucks, and tractors. Circular entitled "Over Fifteen Million a Year," describing the development of the manufacture of Hyatt roller bearings, which was begun in two small buildings, fifteen years ago, and has grown so that today the plant comprises twenty-three buildings containing 1,000,000 square feet of floor space, and turns out over 15,000,000 roller bearings a year.

Allied Machinery Co. of America, 51 Chambers St., New York City. Catalogue Section 11101, illustrating and describing the turning machines made by the American Tool Works Co., Cincinnati, Ohio. Section 15601, illustrating and describing the milling machines made by the W. B. Knight Machinery Co., St. Louis, Mo. Section 16201, showing the grinding machines made by the Greenfield Machine Co., Greenfield, Mass. Section 16210, illustrating the grinding machines made by the Oakley Machine Tool Co., Cincinnati, Ohio. Section 18401, illustrating and describing the cutting-off machines made by the Hurlbut, Rogers Machinery Co., South Sudbury, Mass.

American Kron Scale Co., 430 E. 53rd St., New York City. Catalogue 6, illustrating the use of the Kron scale for weighing materials in warehouses, factories, transportation offices, industrial plants, etc. The catalogue shows the regular line of Kron scales and gives the capacity and platform dimensions. Opposite each scale is shown a typical installation. These scales are of the automatic type, equipped with a direct-reading dial, which makes it unnecessary to adjust weights or make mental calculations in weighing, resulting in a considerable saving of time. They are said to be the only scales constructed on the self-sealing principle, with all parts interchangeable.

TRADE NOTES

Chrobaltic Tool Co. has moved from Chicago, Ill. to Michigan City, Ind.

Hyatt Roller Bearing Co., has moved to larger quarters at Sixth Ave. and 41st St., New York City.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill., announces that its general offices were transferred April 1 to 6 E. 44th St., New York City.

Republic Tool & Mfg. Co., Cleveland, Ohio, has taken over the exclusive sales agency for northern Ohio for the abrasive products of the Waltham Grinding Wheel Co., Waltham, Mass.

F. C. Brand & Co., 27 Warren St., New York City, has been organized by Frank C. Brand, formerly manager of A. G. Butler, Inc., of New York, to handle patternmakers' and foundry supplies.

Ellenwood & Doyle, 29 Great Jones St., New York City, distributors of tin plate, black and galvanized sheets, copper, brass, zinc, etc., have been incorporated under the laws of New York state with a capital of $150,000.

Canton Foundry & Machine Co., Canton, Ohio, announces that its export department is now located on the fifth floor of the Grand Central Palace, International Machinery Exposition, New York City.

Van Norman Machine Tool Co., Waltham, Ave., Springfield, Mass., has moved its New York sales office from 320 Fifth Ave. to 50 Church St., Room 1856. J. D. Apgar is in charge of the New York office.

Ford of France, Inc., 79 Wall St., New York City, announces that it has been appointed sole agent for the export of the hexagon and square-hole drills made by the Detroit Hexagon Drill Co., Detroit, Mich.

Murchey Machine & Tool Co., 34 Porter St., Detroit, Mich., manufacturer of threading tools, has opened an office in Cleveland at 511 Schofield Bldg., in charge of L. W. Arnold. An office has also been opened in New York City at 99 Warren St., with Charles M. Neth in charge.

Lafayette Tool & Equipment Co., Inc., Lafayette, Ind., at its last directors' meeting held at the general sales office, 21 S. 12th St., Philadelphia, Pa., elected the following officers: William M. Manion, president; Joseph M. Stryhal, vice-president; and Dudley Shoemaker, secretary and treasurer.

Buffalo Forge Co., Buffalo, N. Y., at a recent meeting of the stockholders, appointed the following new officers: Henry W. Wendt, president; Edgar F. Wendt, vice-president and treasurer; Henry W. Wendt, Jr., vice-president and secretary; and C. A. Booth, vice-president and sales manager.

Joseph T. Ryerson & Son, Chicago, Ill., has been made representative of the Camden Iron Works in the sale of their hydraulic machinery

Your Pattern Shop Should Be Interested in the

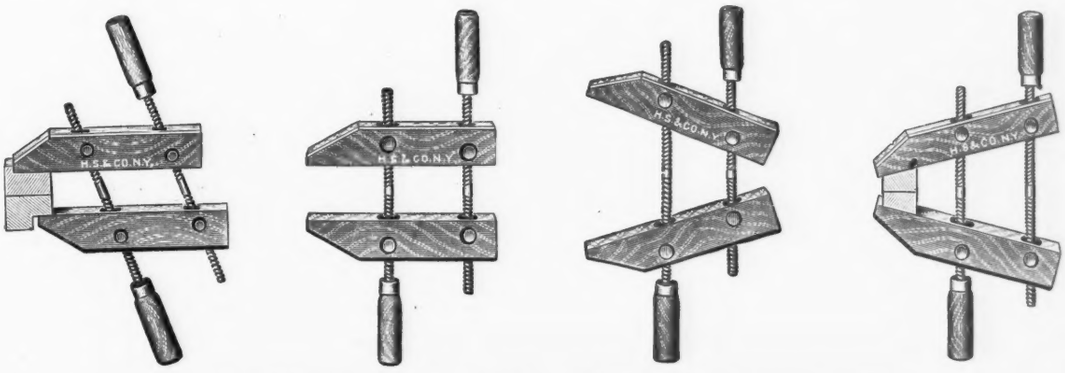
JORGENSEN ADJUSTABLE HAND SCREW

A Necessary Tool in the Shop

The Hand Screw of Many Angles

A SINGLE CLAMP will adjust to any of the positions shown, or any modification of them. One jaw can also be made to overlap the other.

More than that, these Adjustable Hand Screws have Steel Spindles which are practically indestructible. They have a Right and Left thread, and open and close almost twice as fast as old style clamps—more time saved.



Send for Circular No. 551 and read more about them

HAMMACHER, SCHLEMMER & CO.

HARDWARE, TOOLS AND FACTORY SUPPLIES

NEW YORK, SINCE 1848 **4th AVENUE AND 13th STREET**

products. In addition to a complete line of hydraulic tools, this company also makes centrifugal pumps, cast-iron pipe and fittings, and kindred products.

Whitman & Barnes Mfg. Co., Akron, Ohio, announces that the following officers were elected at its last annual stockholders' meeting: A. D. Armitage, president; W. H. Eager, A. B. Hall, and W. J. Elliott, vice-presidents; E. A. Fisher, treasurer; W. E. Rowell, secretary; and S. H. Tuttle, assistant secretary.

Morse Chain Co., Ithaca, N. Y., manufacturer of frictionless rocker joint chains, and high-speed silent-running flexible gearing, announces that the company has opened new offices at 1402 Lexington Bldg., Baltimore, Md., in charge of E. R. Morse, and also at 302 Harrison Bldg., Philadelphia, Pa., in charge of M. H. Rodda.

Ray D. Lillibridge, Inc., 111 Broadway, New York City, has established a foreign department for the purpose of giving advice and assistance to its clients in the matters of export advertising and sales. Maurice Legori, for the last two years manager in Argentina for Viele, Blackwell & Buck of New York, will be manager of the new department.

Oxweld Acetylene Co., Newark, N. J., has recently extended its manufacture of oxy-acetylene apparatus and equipment to include "Eveready" welding and cutting outfits. The "Eveready" apparatus is essentially the same as that previously known as "Prest-O-Lite" apparatus, except for certain refinements in design that have been introduced.

Foster-Johnson Reamer Co., Elkhart, Ind., has been incorporated under the laws of Indiana with a capitalization of $200,000, for the manufacture of the Johnson expansion reamers, which have been made in the past by the Foster Machine Co. The officers of the new corporation are W. H. Foster, president; W. B. Johnson, vice-president; and Oscar Kylin, secretary.

Republic Tool & Mfg. Co., Cleveland, Ohio, because of the rapid growth of its business, has found it necessary to expand its main offices, and the entire second floor of its present building has been remodeled to provide private and general offices of ample capacity. The ground floor and the floors above the second will be utilized for greater warehouse capacity.

Blevney Machine Co., Greenfield, Mass., manufacturer of grinding, polishing, and finishing machinery, announces that the firm name has been changed to Production Machine Co. The company has decided that the word "production" has more significance in connection with its product than the name Blevney. There will be no change in the officers or management of the business.

Golden Co., 405 Lexington Ave., New York City, announces that it has the exclusive American agency for Societe Genevoise d'Instruments de Physique, Geneva, Switzerland, maker of comparators for gaging steel balls, ball bearings, and machine parts; universal measuring machines; reference gages; scientific instruments; and dividing engines for cylindrical, conical, and linear work.

Electric Furnace Co., Alliance, Ohio, has opened a middle western office at 301 Frisco Bldg., St. Louis, Mo., with W. E. Prosser in charge. The increasing demand for Baily electric furnaces for melting non-ferrous metals and the fact that there are at present sixty units of this type in operation within a radius of 500 miles of St. Louis have made it necessary to open an office in this vicinity.

Erie Crucible Steel Co., Erie, Pa., announces the appointment of the Cleveland Steel Supply Co., Cleveland, Ohio, as its agent for the Cleveland district. C. E. Schnibbe, manager of the Cleveland Steel Supply Co., was associated with the Halcomb Steel Co. for twelve years, five of which he was connected with the Cleveland branch of the company and hence is well known in the Cleveland district.

Maher Engineering Co., 30 N. Michigan Blvd., Chicago, Ill., has opened a branch office at 706 Schofield Bldg., Cleveland, Ohio, to handle the distribution of Erie Engine Works' constant- and variable-speed, high- and low-pressure engines; Dayton-Dowd Co.'s centrifugal pumps; and Galland-Henning Mfg. Co.'s hydraulic balers and presses. The office will be under the management of Lincoln E. Maher.

Lafayette Tool & Equipment Co., Inc., Lafayette, Ind., announces that it has appointed the Societe Anonima Italiana Alfred Herbert, 42 Via Sajazzo, Milan, Italy its sole agent in Italy for the sale of the Lafayette universal grinder. The Sherritt & Stoer Co., Inc., 2006-2008 Market St., Philadelphia, Pa., has been appointed exclusive representative for the sale of the Lafayette universal grinder in the Philadelphia district.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has acquired a financial interest in the George Cutter Co. of South Bend, Ind. The management and policies of the company will remain unchanged, but advantage will be taken of the Westinghouse engineering and other facilities to expand the George Cutter Co.'s lines. The Westinghouse Electric & Mfg. Co. will operate as sole distributor for the George Cutter Co.'s products.

Driver-Harris Co., Harrison, N. J., is erecting a three-story building, 52 by 100 feet, to which will be added a 100-foot extension. The upper floor of the building will be used for a general office, the second floor for a spooling and testing room, and the ground floor for the cleaning and shipping departments. It is planned to erect another large building later in the year. The capitalization of the company has been increased to $3,000,000.

Hobart Bros. Co., Troy, Ohio, maker of battery-charging equipment, announces the placing on the market of a new product, consisting of an outfit of 250-watt capacity, capable of recharging from one to four automobile starting and lighting batteries at one time. The outfit is provided with ball bearing equipment, automatic voltage control, ample capacity for rating, and a panel board mounted on top of the motor generator. It is especially designed for the use of small garages.

Toledo Steel Products Co., formerly the Lewis Steel Products Co., is now located in its new plant at 3300 N. Summit St., Toledo, Ohio, which comprises two brick buildings, each being over 400 feet long. The company is at present working with a full force, manufacturing valves for automobiles and marine, stationery and airplane engines. The officers are as follows: A. P. Class, president; W. P. Childs, vice-president and manager; and M. A. Albaugh, secretary and treasurer.

Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, has opened a new store in San Francisco, Cal., at 40-42 Fremont St. This firm has maintained an office in San Francisco for many years, but as the demand for its machines has increased it has been found necessary to open a store to carry a line of machine tools for quick delivery. The store is in charge of C. H. Overkamp, who has been with the company for some years. Additional selling organization is being provided at this time.

Rickert-Shafer Co., 612 W. 12th St., Erie, Pa., manufacturer of the Boehm automatic die-head and the Rickert-Shafer line of automatic tapping machines, announces the following appointments in its organization: A. A. Shafer has been made secretary and general manager; C. W. Howard, formerly with the General Electric Co., has been made general sales manager; A. J. Patterson, formerly with the Crucible Steel Co., has been made general superintendent; and George Paterson has been made production manager.

Meldrum, Semon, Greiner, Lowry Co., Syracuse, N. Y., manufacturer of limit gages and tools, announces that the company has been reorganized under the name of the M. S. G. L. Co., Inc., which has also taken over the Lowry-Knise Tool Co., of Syracuse. The management and the officers of the new company remain the same as in the older concerns. The new company is capitalized for $200,000, and is planning to increase its present manufacturing facilities and to manufacture gages, special tools, and machinery.

Auburn Ball Bearing Co., 33 Elizabeth St., Rochester, N. Y., manufacturer of regular and special ball bearings with steel, brass, and bronze balls, has moved its offices into an adjoining building which has been renovated and equipped for the purpose. The company is now devoting the entire former floor space of its past quarters to manufacturing purposes. New storage space has also been added, providing additional space for the manufacturing departments, and thereby making it possible to considerably increase the company's manufacturing capacity.

Oakley Chemical Co., 26 Thames St., New York City, is offering $500 in prizes for the best articles written on the importance of cleaning as an essential manufacturing operation. The four best articles will receive prizes of $100, $75, $50, and $25, respectively, and the next twenty-five articles $10 each. The winning articles will be published in the "Oakite News Service," issued by the Oakley Chemical Co. The articles are not to exceed 2000 words in length, and preference will be given to those of about 1500 words. The contest closes April 19. Further information will be furnished by the contest editor, Oakley Chemical Co., 26 Thames St., New York City.

F. W. Lindgren Co., Rockford, Ill., manufacturer of sensitive drilling machines, has been absorbed by the **Mechanics Tool Co.** of Rockford. The combined capitalization is $150,000. The Mechanics Tool Co. is now located in its new plant on 23rd Ave. and 7th St., and will manufacture, on a large scale, the Lindgren sensitive drilling machines in 16-, 20-, and 24-inch sizes, with tapping attachment. The company will also continue its own line of hand tools and automobile parts. Considerable new equipment has been installed. The officers are E. S. Ekstrom, president; F. W. Lindgren, vice-president; O. N. Swangren, secretary; and Levine Faust, treasurer.

Cincinnati Automatic Machine Co., Oakley, Cincinnati, Ohio, manufacturer of automatic screw machines, announces that the company has acquired the manufacturing, selling, and patent rights to the Gridley automatic multiple-spindle drilling machine formerly made by the Windsor Machine Co., Windsor, Vt. This machine will be sold by the Cincinnati Automatic Machine Co. under the name Cincinnati-Gridley automatic multiple-spindle drill, and will be manufactured in quantities along with the company's multiple-spindle automatic screw machines. The manufacture will be handled in a new shop, which will largely increase the productive capacity of the present plant.

Black & Decker Mfg. Co., Towson Heights, Baltimore, Md., has sold its Baltimore plant at 105-115 S. Calvert St. to the Dieffenbach-Westendorf Mfg. Co., which is composed entirely of former employes of the Black & Decker Mfg. Co. The officers of the new company are as follows: O. W. Dieffenbach, formerly manager of the Baltimore plant, president; William Westendorf, formerly superintendent, vice-president and general manager; John Sonnenleiter, formerly foreman of the milling machine department, secretary. George M. Kimberly, who has been treasurer of the Black & Decker Mfg. Co., for a number of years, will also occupy the position of treasurer with the new company.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has contracted with Westinghouse, Church, Kerr & Co. to build four new buildings at South Philadelphia, Pa. This expansion is intended to take care of the immediate needs incident to the removal of the Machine Works (formerly the Westinghouse Machine Co.) from East Pittsburg. The four buildings will comprise a one-story machine shop, 500 by 130 feet, which will be used for building small turbines for operating pumps and generators; a one-story machine shop, 750 by 130 feet, which will be used for building large steam turbines; an extension to the erecting shop of 300 feet adjoining the new machine shops; and a three-story warehouse 600 by 50 feet, the third floor of which will be used for manufacturing purposes.

American Chain Co., Inc., Bridgeport, Conn., has purchased the control of the **Page Steel & Wire Co.** with mills at Monessen, Pa. and Adrian, Mich. It is the intention of the American Chain Co., Inc., to continue the business of the Page Steel & Wire Co. as heretofore, taking only its surplus products. The new officers of the company are Walter B. Lashar, president; William T. Morris, vice-president; Wilmot F. Wheeler, treasurer; John E. Carr, assistant treasurer; and William M. Wheeler, secretary. E. C. Sattley, general manager of the Page Steel & Wire Co., will continue in that capacity with offices in Pittsburg, Pa. The general sales offices of the American Chain Co. are in the Grand Central Terminal Bldg., New York City, and it maintains district sales offices in Chicago, Boston, Philadelphia, San Francisco, Portland, and Pittsburg.

George D. Roper Corporation, Trahern Pump Division, Rockford, Ill., announces that the amalgamation of the **Trahern Pump Co.** with the George D. Roper Corporation will enable an increase of 50 per cent in the production of Trahern pumps. As yet only the foundry section of the new plant being built is complete and in operation. The entire plant, when completed, will cost approximately $1,500,000, and is located on a tract of land purchased for the purpose at Rockford, Ill. The Trahern Pump Co., which started in business in 1857 and has built up a nationally known name and reputation, will not lose its individuality through the merger, and all correspondence addressed to it should be directed to the George D. Roper Corporation, Trahern Pump Division, Rockford, Ill. The Trahern pump line includes the rotary geared circulating pump well known in the machine tool industry, and also large rotary pumps for general uses.

Gage Engineering Service Co., 1422 F St., N.W., Washington, D. C., is organized and equipped to extend to manufacturers technical service, and as a means of keeping them regularly informed regarding recent developments is issuing a monthly report known as "Technical Service Report," which gives the names and nature of contents of articles appearing in current American and several foreign trade and technical journals and of papers presented before technical societies pertaining to gaging, inspection, testing; tools, jigs, and fixtures; cutting and finishing of metals; and composition, structure, and heat-treatment. The report also gives the names and brief reviews of new books which have a bearing on inspection and production; brief descriptions of new equipment such as gages and inspection fixtures, production tools and fixtures, and cutting tools; and photostat copies of patents which apply to gages, measuring instruments, tools, jigs, and fixtures, as published in the "Official Gazette" of the United States Patent Office.

J. H. Williams & Co., 61 Richards St., Brooklyn, N. Y., announces that a special meeting of the stockholders of the company, in conjunction with the stockholders of the Whitman & Barnes Mfg. Co. of Akron, Ohio, has been called for April 2, for the purpose of ratifying an agreement entered into by the respective presidents of the companies, made subject to the approval of the stockholders, for the merging of the Chicago, Ill., and the St. Catharines, Ontario, Canada, plants of the Whitman & Barnes Mfg. Co. with J. H. Williams & Co. When ratified, this plan will contemplate the operation by J. H. Williams & Co. of drop-forging and drop-forged tool plants at Brooklyn, N. Y., Buffalo, N. Y., and West Pullman, Chicago, Ill., in the United States, and at St. Catherines, Ontario, Canada, which is located close to Buffalo; the business will be operated by the same management as is now connected with these plants. The plans of J. H. Williams & Co. under this arrangement call for a considerably extended capacity. The Whitman & Barnes Mfg. Co. will continue its business of making twist drills, reamers, and collateral lines on an extended scale at Akron.